Wetland
Studies and Solutions, Inc.®

November 5, 2010

The Honorable Doug Domenech
Secretary of Natural Resources
Commonwealth of Virginia
Patrick Henry Building
1111 East Broad Street
Richmond, VA 23219

VIA U.S. MAIL AND
EMAIL: vabaytmdl@dcr.virginia.gov

Water Docket
Environmental Protection Agency
Mailcode: 25221T
1200 Pennsylvania Avenue, NW
Washington, DC 20460

VIA U.S. MAIL AND
http://www.regulations.gov

Re: Docket Number EPA-R03-OW-2010-0736
Comments on the:
Commonwealth of Virginia
Chesapeake Bay TMDL
September 2010 Draft Phase I Watershed Implementation Plan (draft WIP)

Dear Secretary Domenech:

I sincerely appreciate the opportunity to provide comments to you regarding the referenced draft WIP. I have had the honor of serving as a member of the Stakeholder Advisory Group (SAG) you developed for providing input to you and your staff during the development of the draft WIP. It is unfortunate that the WIP development process was condensed into such a short period of time due to EPA's decision to complete this WIP process by the end of the year despite their ±6 month delay in delivering the load allocations to the Commonwealth.

The result is that the public has been done a disservice because there was *not* sufficient time for a WIP to be developed that is *cost effective* and that *equitably* shares the costs of cleaning up the Bay across society, yet these two criteria were the foundation of agreement by the Commonwealth of Virginia's SAG.

I am optimistic that, with modification, the draft WIP proposed by the Commonwealth could easily become the most cost-effective and equitable solution to the TMDL problem that is acceptable to the EPA. This WIP would benefit the citizens of the Commonwealth by cleaning the Bay *and* local rivers and streams in the most affordable way possible.

Exhibit 1 (Proposed WIP Modifications) provides Sector Allocations and Action Items for your review that could be used to create such a WIP. The Action Items are designed to build upon

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(not substitute) the draft WIP in a manner that utilizes its innovative nutrient exchange concepts and achieves the TMDL allocation goal in the most cost effective and equitable manner.

The discussion below highlights the reasons why the current draft WIP and the EPA backstop are not desirable to the citizens and economy of the Commonwealth. The discussion also provides technical and cost data to support these assertions, followed by an explanation of why the Proposed WIP Modification allocation and Action Items are reasonable and superior to the proposals on the table from the Commonwealth and the EPA.

The following seven Action Items (and associated Sector Allocations outlined in Exhibit 1) can improve the draft WIP and achieve the TMDL allocations for Virginia at a lower total cost to society as summarized in Table 1, below (See Section III., Table 6, for calculations and data sources):

1. Upgrade All Significant Discharger Wastewater Treatment Plants
2. Establish Urban Fertilizer Regulations
3. Expand 5-Year On-Site Pump Out Requirement
4. Improve Erosion and Sediment Control Training and Specifications
5. Establish a "Nutrient Trading Fund"
6. Allow New Construction with On-Site Sewage Disposal to Exceed NSF/ANSI Standards or Contribute to the Nutrient Trading Fund
7. Allow Development Exceeding the Allowable WIP Loads to Contribute to the Nutrient Trading Fund

Table 1: Urban Sector Cost Comparison of Draft WIP, EPA Backstop, and Proposed WIP Modification

Plan	Cost by Sector (Billion $)				Cost/capita	
	WWTP	Urban	Septic	Total	Total	Yearly[1]
Draft WIP (without trading)	0	45.2	0.5	45.7	$7,614	$507
EPA Backstop	2.9	12.5	0.5	15.9	$2,649	$177
Proposed WIP Modification	5.2	3.0	0.5	8.7	$1,449	$97
EPA Urban Retrofit Estimate [2]	--	41.6	--	--	$6,930	$462

[1] Over 15 years

[2] Derived from US EPA, 2009. The Next Generation of Tools and Actions to Restore Water Quality in the Chesapeake Bay, A Draft Report Fulfilling Section 202a of Executive Order 13508 (Page 23). U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis, MD. (Page 23.)

I. Draft WIP Concerns

A. Sector Warfare and Equity

Separating the total loadings of pollutants by sector (i.e. Agriculture, Urban Runoff, Wastewater, On-Site Septic, Forest and Non-Tidal Deposition) without clearly articulating the interconnection of some sectors leads to unnecessary conflict and a loss of one critical, big-picture item: that the vast majority of the people who contribute to detrimental urban runoff are also the people connected (through home and/or work) to a Wastewater Treatment Plant (WWTP). WWTPs are funded by a combination of "tap fees" (fees charged for new connections for compensation of system capital costs attributed to new users) and user fees to pay for plant upgrades and their operation and maintenance costs. These same "WWTP users" occupy housing, utilize shopping centers, work in office and industrial facilities, drive on roads, and utilize public facilities. The very lifestyles of these WWTP users cause the existence of surfaces that create urban runoff[3]. Thus, these two sectors are inexorably linked and should be examined collectively in relationship to the other sectors. Allocations for both should be developed to achieve the *total* desired pollutant reduction in the most cost-effective manner. The same people will pay for upgrades to WWTPs and/or urban stormwater retrofits through either general revenue taxes, storm utility fees, or stormwater service district taxes.

B. Cost Effectiveness and Practicality

1. Urban Runoff

The proposed Draft WIP input deck applies E3 (Everything by Everyone Everywhere) levels of stormwater management retrofit to *all* urban lands[4]. This makes EPA's backstop proposal of requiring 50% of urban MS4 lands and 25% of unregulated lands to meet "aggressive performance standards through retrofit/redevelopment" seem reasonable when compared to the draft WIP, although it is still not practicable, as discussed below.

Over the next 15 years, redevelopment will have an insignificant impact on urban runoff reductions; urban retrofits (independent of redevelopment) will be necessary for more substantial reductions in urban pollutant loads. The Phase 5.3 Chesapeake Bay Community Watershed Model (Bay Model)[5] indicates a total of 266,438 acres of

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[3] There is also, of course, urban runoff from low-density developed areas whose sewage is handled by on-site septic systems, so the correlation is not perfect. However, in low-density development areas, more of these surfaces are "disconnected impervious surfaces" which are commonly accepted as a low-impact development technique because much of the runoff can sheet-flow into pervious areas to be filtered, infiltrated, or evapotranspired. Disconnected impervious surfaces have less of an effect upon water quality than similar surfaces in higher-density areas (those commonly served by WWTPs). For example, in the Occoquan Watershed in Fairfax County, Virginia, non-structural Best Management Practices (BMPs) in the form of minimum size five acre lot zoning without SW/BMPs has protected the Occoquan Reservoir's water quality since the mid-1970s. (Higher density areas in this watershed must provide SWM/BMPs.)
[4] Based on EPA Comments on Virginia's Draft WIP, 10/4/2010. (Page 6.)
[5] Version released 7/21/ 2010.

impervious surface in Virginia's portion of the Bay watershed (150,340 high density acres and 116,098 low density acres) existed in 2009. Even if half of all development projected in the Bay Model is redevelopment and reduces loads by 50% (an unlikely level of redevelopment and a very aggressive load reduction assumption with regulations currently at 10% and proposed to be 20%), total loads would only be reduced by 8%[6] by 2025, nowhere near Virginia's proposal to reduce TN and TP by 45% and 59% respectively compared to 2009 loads[7].

Thus, the vast majority of the proposed Urban sector pollutant reduction can only occur if existing impervious surfaces are retrofitted. Exhibit 2 (Cost Effectiveness of Pollutant Removal Options for the Urban Sector Population) provides calculations and data sources for the following order-of-magnitude estimates for urban pollutant reductions and costs associated with the EPA backstop and the draft WIP shown in Table 2, below.

Table 2: Order-of-Magnitude Cost Estimate for Urban Retrofit Proposals

Nutrient Reduction Option	Capital Cost ($ Billion)	O&M Cost (Present Worth, $ Billion)	Total Cost ($ Billion)	Total Removed (Million lbs/yr)		Removal Cost[8] ($/lb-yr)	
				TN	TP	TN	TP
Urban Retrofit (EPA Backstop[9])	10.7	1.8	12.5	1.34	0.24	6,000	33,500
Urban Retrofit (Draft WIP)	38.7	6.5	45.2	2.95	0.82	6,000	33,500

Notwithstanding the extraordinary cost, retrofitting 266,000 acres of imperviousness under the current draft WIP (or even 104,000 acres under the EPA backstop) is simply not practicable. Additionally, the next version of the Bay Model is expected to *double* the impervious area[10], which will also double the retrofit requirement. It is difficult to imagine trying to design, construct, and maintain enough rain gardens (with a maximum drainage area of one acre) to treat these surfaces (including every VDOT highway and subdivision street) compared with upgrading 126 significant WWTPs. Clearly, upgrading WWTPs is considerably more practicable from a management perspective.

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[6] The Bay Model 2009 Progress Model Year indicates 13,965 acres of bare construction. The model documentation (US EPA, 2008. Chesapeake Bay Phase 5 Community Watershed Model, Chapter 4 (Page 4-18). U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis, MD.) states an assumption that 40% will become impervious surfaces (40% x 13,965 acres = 5,586 acres); 5,586 acres/year x 15 years x 50% Redevelopment x 50% Removal Rate / 266,438 acres x 100% = 7.86% Removal from Redevelopment.
[7] EPA Comments on Virginia's Draft WIP, 10/4/2010 (Page 6.)
[8] Urban Retrofit - 50/50 cost allocation between TN/TP
[9] Total Area = 50% of high density impervious and 25% of low density impervious
[10] Based on an a memo dated 5/25/2010 received from Peter Claggett (USGS) to Mike Rolband (WSSI), pervious and impervious surfaces are likely to change by a factor of 2 to 3.

2. Wastewater

The Draft WIP proposes no WWTP improvements beyond current permit requirements, which is vastly different than the requirements placed on other sectors. The lack of requirements on the Wastewater sector is not cost effective as it places a larger financial burden on the same segment of the population compared to other available options. The EPA backstop proposes 4.0 mg/L for TN and 0.30 mg/L for TP for Virginia; yet, for Delaware, Pennsylvania, New York, and West Virginia, the EPA proposed a more restrictive backstop of 3.0 mg/L and 0.10 mg/L. Table 3 puts these numbers in perspective:

Table 3: Flow Weighted Average for Concentrations (mg/L) used for Current WLAs for Significant Dischargers by basin

Basin	Flow weighted Average **Concentration** (mg/l)[11]	
	TN	TP
Shenandoah-Potomac	4.12	0.20
Rappahannock	4.00	0.30
York	3.08	0.50
James	6.95	0.65
Eastern Shore	4.93	0.30
TOTAL Flow Weighted Avg:	**5.55**	**0.48**

Furthermore, in the Potomac Embayment, the following WWTPs already operate at TN concentrations of 3.0 mg/L and TP concentrations of 0.18 mg/L:

- Quantico Wastewater Treatment Facility;
- Aquia Wastewater Treatment Facility;
- Dale Serv. Corp – Section 1 & 8 Wastewater Treatment Facilities;
- H L Mooney Wastewater Treatment Facility;
- Arlington County Water Pollution Control Facility;
- Alexandria Sanitation Authority Wastewater Treatment Facility; and
- Norman M Cole Jr. Pollution Control Facility.

A recent article in the Washington Post titled, "Potomac River now healthier than in '50s, study shows,"[12] discussed the dramatic changes in the Potomac River (TP concentration of 0.20 mg/l) since the 1960s and attributed the turnaround to upgrades at the Blue Plains

[11] Current concentrations were calculated from design flows and waste load allocations which were provided by Russ Baxter (DEQ- Chesapeake Bay Program) via e-mail on 9/21/2010.
[12] Published on 9/7/2010. Full article is located in Exhibit 3 and is available at the following website: http://www.washingtonpost.com/wp-dyn/content/article/2010/09/07/AR2010090703555.html?wpisrc=nl_localpolalert.

treatment plant. (See Exhibit 3, "Potomac River now healthier than in '50s, study shows.") In stark comparison is the current condition of the James River with significantly less stringent WWTP requirements (TP concentration of 0.65 mg/l). An article in The Virginia-Pilot titled, "Algae blooms strike Hampton Roads waters – again,"[13] discussed the recurrence of algae blooms in the Hampton Roads area and cited "industrial dischargers" as one source of the problem. (See Exhibit 4, "Algae blooms strike Hampton Roads waters – again.") The direct link between water quality and the WWTP effluent concentrations shown in Table 3 is clear.

It seems unreasonable for people in one portion of the Bay watershed to provide such cleaner discharges than others. First, equity suggests that all of the Bay watershed operate below 3.0 mg/L and 0.18 mg/L. Second, a look at cost-effectiveness shows that EPA's backstop for WWTPs in DE, NY, PA, and WV (3.0 mg/l TN and 0.10 mg/l TP) is actually the most reasonable proposal because it reduces the *total* cost of nutrient removal throughout the watershed, as briefly discussed above in Section A.

The arguments against further upgrades to WWTPs include:

a) "They" have already spent a lot of money to upgrade their plants and it is unfair to ask for more; and
b) "They" have already done more than their fair share of load reductions since 1985.

However, Pogo[14] once said, "we have met the enemy and he is us," and that wisdom applies in this case as well. The arguments above are inappropriate because, again, "they" are not WWTP operators; "they" are rate payers, the urban/suburban dwellers who ultimately pay for these plants, but who also pay for urban stormwater upgrades through fees or taxes. The WIP needs to compare the cost-effectiveness of upgrading WWTPs[15] to other options faced by the same people: the rate payers, *not* the WWTP operators.

Exhibit 2 also contains an order-of-magnitude cost estimate using Bay Program data for four WWTP nutrient reduction options, as summarized in Table 4, below:

[13] Published on 8/12/2010. Full article and photos are located in Exhibit 4 and are available at the following website: http://hamptonroads.com/2010/08/whats-behind-red-tide-algae-blooms-strike-regions-waters-again.
[14] Walter Kelly, Earth Day Poster, 1970.
[15] To concentrations of TN = 3.0 mg/L and TP = 0.10 mg/L from today's levels (since costs increase dramatically as treatment levels tighten).

Table 4: Order-of-Magnitude Cost Estimate for WWTPs

Nutrient Reduction Option	Capital Cost ($ Billion)	O&M Cost (Present Worth, $ Billion)	Total Cost ($ Billion)	Total Removed (Million lbs/yr)		Removal Cost ($/lb-yr)	
				TN	TP	TN	TP
WWTP (EPA Backstop)	1.7	1.2	2.9	5.70	0.54	250	2,700
WWTP (LOT[16])	2.9	2.3	5.2	8.31	1.14	250	2,700
WWTP (Potomac Embayment)	2.6	1.9	4.5	8.31	0.87	250	2,700
WWTP (Draft WIP)	0	0	0	0	0	N/A	N/A

An examination of Tables 2 and 4 shows that WWTP upgrades are roughly an order of magnitude (approximately ten times) more cost-effective than urban stormwater management retrofits per pound of pollutant removed. Therefore, the requirement to retrofit urban areas in lieu of upgrading WWTPs will result in a much greater cost burden on urban- and suburban-dwelling citizens of the Commonwealth, as discussed above.

3. Urban Nutrient Management

The SAG voiced support for implementing Urban Nutrient Management, which proposes to reduce the pollutants running off urban surfaces by regulating how those nutrients may be applied to urban surfaces in the first place. (See Exhibit 5, Effects of Fertilizer Management Practices on Urban Runoff Water Quality[17].) Governor McDonnell has also voiced his support for urban nutrient management, noting that he was the patron of legislation to ban phosphorus in detergents in the Commonwealth as an incredibly cost-effective nutrient management strategy. However, the draft WIP only noted that urban nutrient management regulations would be "considered" and "investigated."

As shown in Charts 1 and 2, below, the potential reductions achievable through urban nutrient management are significant; proper implementation of nutrient management has the potential to save at least 125,000 lb/year TP and 465,000 lb/yr TN at an insignificant cost (less than $10/year[18] for a quarter-acre lot). In fact, in some markets, this could be a *no-cost* reduction[19].

[16] Limits of Technology (TN = 3.00 mg/L; TP = 0.10 mg/L)
[17] Daniels, W., Goatley, M., Maguire, R., Sample, D., 2010. Effects of Fertilizer Management Practices on Urban Runoff Water Quality. Virginia Polytechnic Institute and State University and Occoquan Watershed Monitoring Lab.
[18] Based on conversations with industry experts and cost comparisons at retail stores in July, 2010. Assuming the approximate cost of straight urea fertilizer is $0.80/pound applied and poly- or sulfur-coated urea fertilizer is $2.30 to $2.70/pound applied (an expensive Slow Release Nitrogen Source), with 1 lb/slow release Nitrogen per 1000 sf/year used and no extra cost for including Phosphorus in the fertilizer.
[19] A comparison of Fairway Formula GreenView fertilizer at Merrifield Garden Center in Gainesville, Virginia, on 11/2/ 2010, showed three formulas (29-2-10 Fall fertilizer; 30-0-12 Fall fertilizer with 3/5ths SRN; and 31-0-0 Late Fall fertilizer with 9/10ths SRN) each priced at $39.99 for an amount covering 5,000 square feet.

Chart 1. TP Loads Achievable through Urban Nutrient Management in Virginia

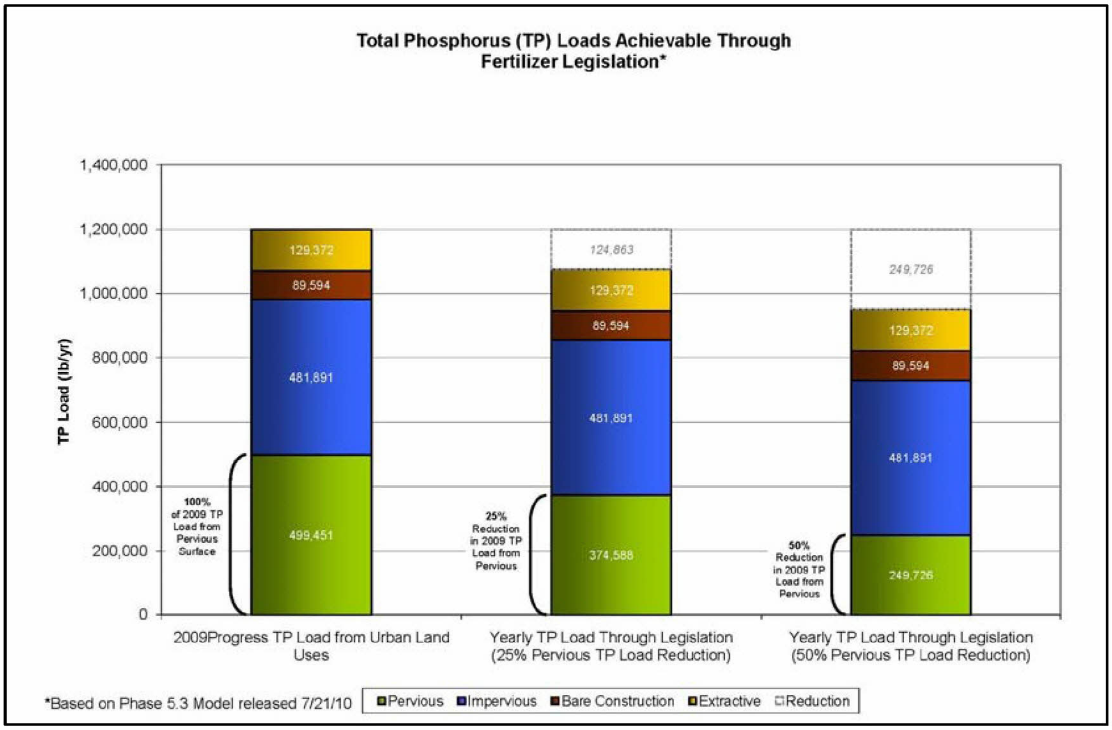
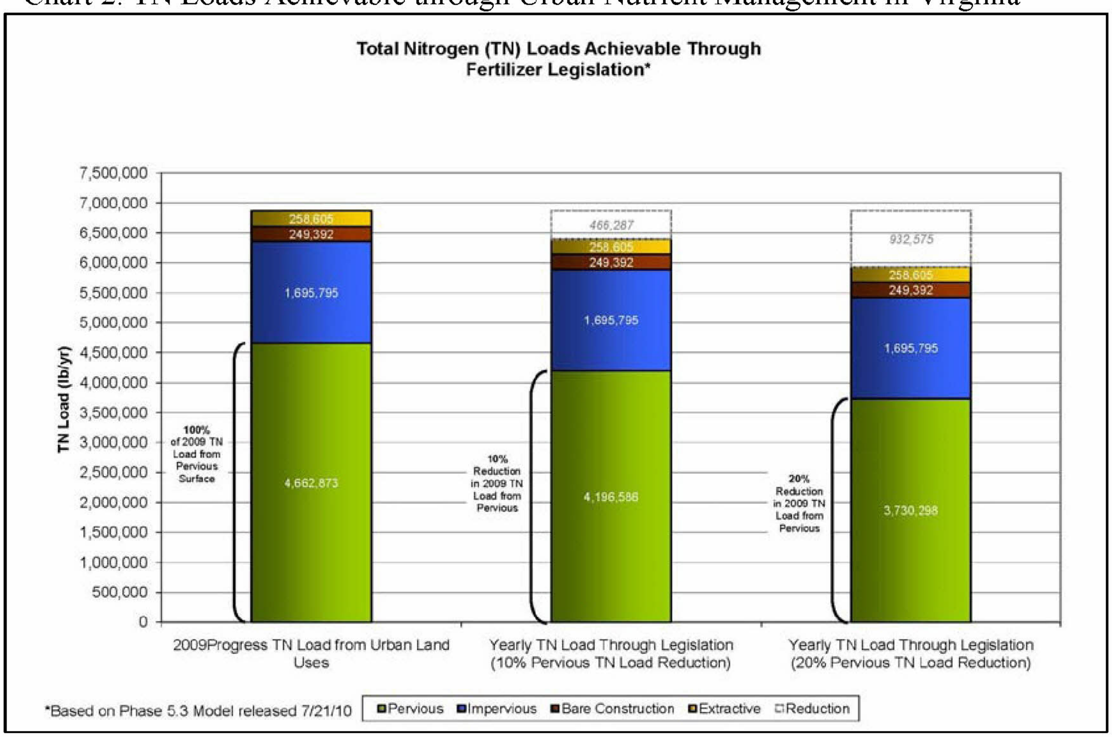


Chart 2. TN Loads Achievable through Urban Nutrient Management in Virginia



4. Nutrient Trading Exchange

The Nutrient Trading Exchange (NTE) outlined in the draft WIP does not currently exist as proposed; considerable time and effort will be needed to establish and expand the program to the point where it operates efficiently as outlined in the Draft WIP. In addition, as currently planned, the NTE does not propose perpetual credits from WWTPs; perpetual credits will be critical in order for the Urban sector to offset its perpetual loads. Without these credits to help offset the E3 levels of stormwater management retrofit to all urban lands in the Draft WIP input deck, the Urban sector is faced with an insurmountable task.

The NTE should also be enhanced with a trading fund, which should be set up before the NTE is finalized in order to generate income for the program as soon as possible. This is described in further detail in Section III.A.5, below.

II. Additional WIP Considerations

A. Reasonable Assurance and Safety Factor

The sectors are not equal in their ability to provide reasonable assurance of nutrient removal both because some technologies are older and more well-established than others and because some sectors physically require fewer management practices and less maintenance. The following list ranks the sectors by their ability to provide reasonable assurance in meeting their nutrient reduction goals (from highest safety factor to lowest):

1. Major WWTPs

Major WWTP upgrades will require upgrading relatively few point sources (as opposed to thousands of urban BMPs). Upgrades utilize well-established technology and can be performed at the lowest cost overall, thereby providing the highest level of reasonable assurance. However, it will be difficult, if not impossible, to obtain perpetual nutrient trading credits due to legal considerations preventing public boards from obligating future elected or appointed boards to financial commitments in perpetuity.

2. Minor WWTPs

Minor WWTP upgrades will require upgrading relatively few point sources (as opposed to thousands of urban BMPs). Upgrades utilize well-established technology, although minor WWTPs are more expensive to upgrade than major plants. Also, because more Minor WWTPs are in operation, it is more difficult to implement improvements in them than in Major WWTPs. However, if the Commonwealth is not on track to meet the TMDL goals at the 2017 mid-course correction point, upgrading Minor WWTPs is a logical next step.

3. Agriculture

Agricultural BMPs are more cost effective than urban retrofits, but upgrades will require many facilities on the ground and considerable technical assistance (Soil and Water Conservation Districts will need financial support and considerable manpower) making it difficult to implement, therefore providing a lower level of reasonable assurance than compared with major WWTP upgrades. For most of these practices the technology required is well-established and relatively inexpensive, but they require ongoing follow-up to ensure that the practices continue to be implemented (i.e. cover crops need to be planted and monitored on an annual basis). The Agriculture sector will need considerable technical assistance to implement BMPs; however, that extensive VT Cooperative Extension funding cuts are planned, which will significantly hinder the ability for the Agriculture sector to put BMPs in place. As compared to WWTPs, it is considerably easier to obtain perpetual nutrient trading credits from the Agriculture sector through agricultural land conversion (i.e. permanent stream buffer fencing and reforestation).

Historically, approximately half of the nutrient load decreases from agricultural land are the result of land conversion (i.e. removing agricultural land from production and converting it to another land use, typically forest or urban), while the other half results from BMPs. For example, 39% of the agricultural TN load decrease in Virginia from 1985 to 2009 resulted from land conversion (Chart 3)[20]; 72% of Virginia's agricultural TP load decrease resulted from land conversion (Chart 4); and 46% of Virginia's agricultural sediment load decrease resulted from land conversion (Chart 5).

[20] To understand the effects of land conversion on agricultural loadings for TN, TP, and TSS in Virginia, WSSI converted the percent decrease in total agricultural land between 1985 and 2009 (11.7%) to a percent decrease in nutrient and sediment load (also 11.7%, since the two are directly proportional). WSSI then subtracted that from the total percent change in load between 1985 and 2009. The resulting value equates to the load associated with BMP implementation (based on the Phase 5.3 Model, released 6/14/10).

Chart 3. Effect of Land Conversion on Virginia Agricultural Total Nitrogen Loads

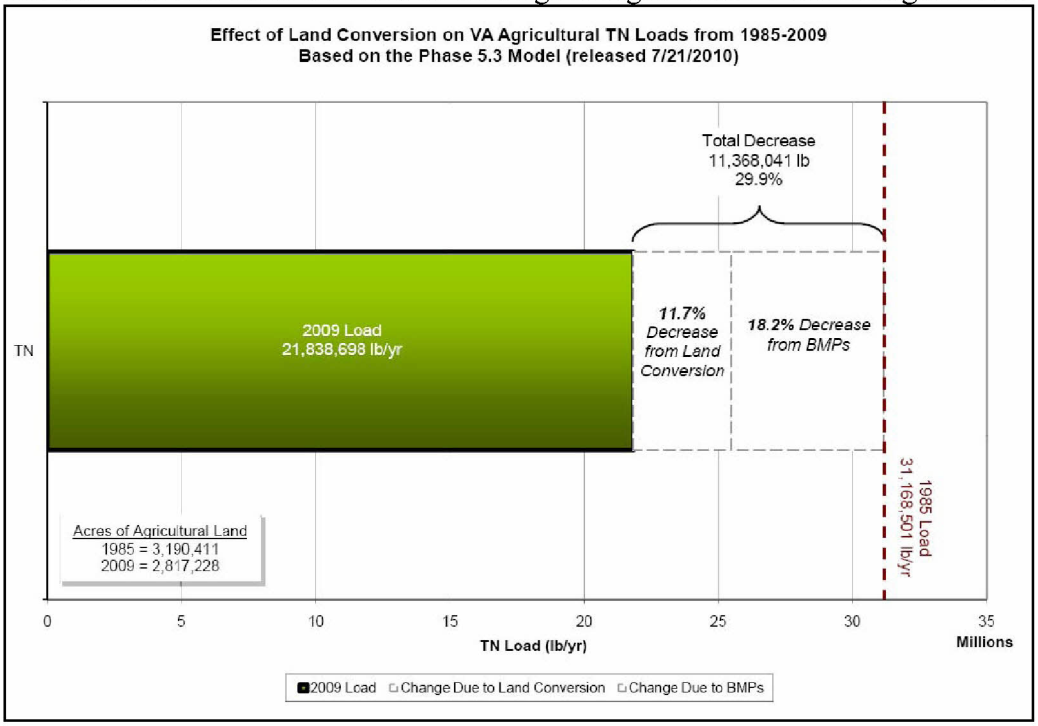


Chart 4. Effect of Land Conversion on Virginia Agricultural Total Phosphorus Loads

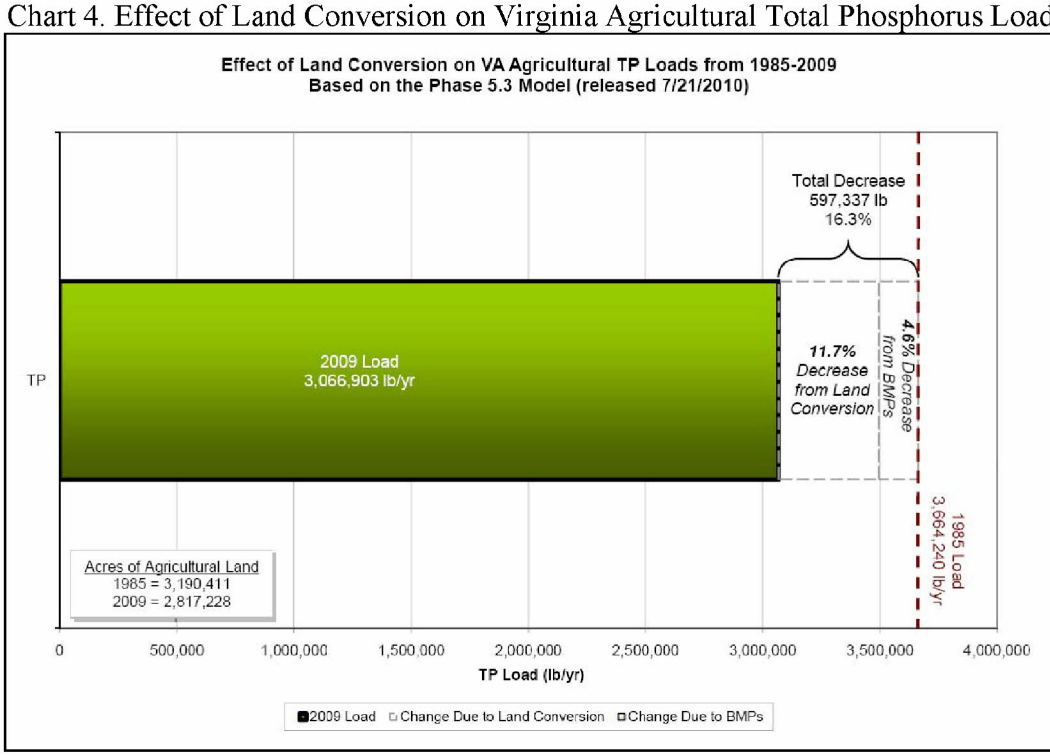
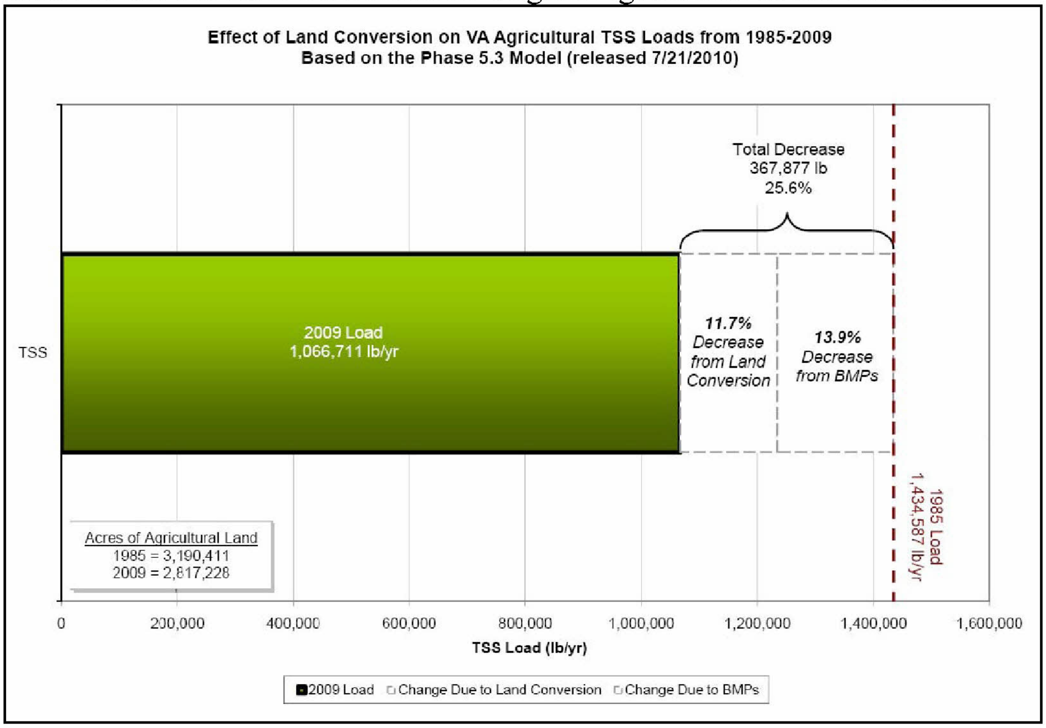


Chart 5. Effect of Land Conversion on Virginia Agricultural Sediment Loads



4. Urban stormwater

   Retrofits of impervious urban surfaces will require a significant number of facilities on the ground; however, it is impossible obtain an accurate number of the facilities needed until the urban acreages in the Bay Model are finalized in 2011. Low-impact development technology is relatively new; therefore, nutrient removal efficiencies for each practice are not well-established, and long-term maintenance requirements have not yet been determined. Additionally, retrofitting impervious surfaces is an extremely expensive means of pollutant removal on a cost-per-pound basis. These uncertainties give urban stormwater retrofits a very low level of reasonable assurance that they will be effective in meeting EPA's TMDL nutrient allocations and the Commonwealth's goals.

B. Growth

The draft WIP states, "Allocations for newly developed land will be set at a level that results in no increase above allowable 2025 average nutrient loads per acre from previous and uses; unless offsets are obtained in the event on-site controls will not fully achieve allowable loads[21]." This requirement will result in an allowable loading of 0.26 lb/ac/yr TP[22] (based on draft WIP allocations and 2010 acreages), as shown in Table 5, below:

[21] September 2010 Draft Phase I Watershed Implementation Plan. (Page 13.)

Table 5: Analysis of 2025 Unit TN and TP Loads Across Sectors in Virginia

	2025 WIP Allocation[23] (lb/yr)		Area[24] (ac)	Load (lb/ac-yr)	
	TN	TP		TN	TP
Forest	13,939,000	1,090,000	9,776,274	1.43	0.11
Agriculture	16,391,000	2,146,000	2,836,970	5.78	0.76
Urban	3,915,000	380,000	1,180,696	3.32	0.32
Total	34,245,000	3,616,000	13,793,940	2.48	0.26
Average of Forest and Agriculture[25]	30,330,333	3,236,000	12,613,244	2.40	**0.26**

Since the draft WIP allocations for the Urban sector will directly influence upcoming stormwater regulations, it is important to understand the effect various allowable loads will have on pollutants in the Bay (yearly and in 2025). Table 6, below, calculates the difference in yearly loads between an allowable loading rate of 0.26 lb/ac/yr (draft WIP) and 0.45 lb/ac/yr (2010 proposed stormwater regulation).

Table 6: Effect of Stormwater Management Regulations

Land Use	Area (ac)	TP Unit Load (lb/ac/yr)	Total TP Load (lb/yr)
Total Bare Construction[26]	13,965	0.26	3,631 lb/yr
		0.45	6,284 lb/yr
Annual Difference			**2,653 lb/yr**
Total Difference in 2025			**39,795 lb**

Table 6 indicates a difference of only 40,000 lbs in the *total* TP load change (2,700 lb/yr) between the two unit loads currently under consideration for the upcoming stormwater regulations. This is approximately 0.06% of the draft WIP-allocated annual TP load for the Urban sector (3,915,000 lb/yr); it is truly a trivial point of contention[27] and can be handled easily through the proposed Nutrient Trading Fund (see Section III.B.5, below).

[22] The table also results in an allowable TN load of 2.40 lb/ac/yr, but the proposed stormwater regulations only regulate TP as currently written. Therefore, no further mention of TN is made in this section.
[23] 2025 WIP allocations are from the September 2010 Public Review Draft WIP.
[24] The 2010 sector acreages shown here were received from Russ Perkinson via e-mail on 8/12/2010.
[25] This calculation assumes that "2025 average nutrient loads per acre from previous land uses" are the loads resulting from the straight average of forest and agriculture.
[26] In Virginia for the 2009Progress model year; based on the Phase 5.3 Chesapeake Bay Model, released 7/21/2010.
[27] In fact, the *total* load change is only 1% of the *yearly* allowable load from the Urban sector.

III. Proposed Changes to the Draft WIP

The discussion below presents specific modifications to the Draft WIP that achieve the EPA load allocation goals in a more cost-effective manner than that Draft WIP proposal (a summary of the proposed load allocations and the actions required to achieve the allocations for the Proposed WIP Modification is presented in Exhibit 1). Table 7 provides a cost analysis comparison for the Draft WIP, EPA backstop, and the Proposed WIP Modification.

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Table 7: Urban Sector[28] Cost Comparison of Draft WIP, EPA backstop, and Proposed WIP Modification

Plan	Cost by Sector (Billion $)[29]				Cost/capita[30]	
	WWTP	Urban	Septic	Total	Total	Yearly
Draft WIP (without trading)	0	45.2	0.5	45.7	$7,614	$507
EPA Backstop	2.9	12.5	0.5	15.9	$2,649	$177
Proposed WIP Modification	5.2	3.0[31]	0.5	8.7	$1,449	$97
EPA Urban Retrofit Estimate[32,33]	--	41.6[34]	--	--	$6,930	$462[35]

The analysis in Table 7, above, shows that the most cost-effective plan for the Commonwealth, in terms of both the total cost and the per-capita cost, is the Proposed WIP Modification presented in Exhibit 1.

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28 Includes Wastewater, On-site and Urban sectors.

29 See Exhibit 2 for sector cost estimates.

30 6,001,681 people in the Chesapeake Bay portion of Virginia. Calculated from 2009 US Census estimate (http://www.census.gov; last accessed 7/6/2010), using Chesapeake Bay Watershed boundary GIS information (ftp://chesapeakebay.net) and the ESRI Virginia County dataset. Where only a portion of a county falls within the watershed, the county population in the watershed is determined by calculating the population of the county (based on the 2009 US Census estimate) times the percent of the county area within the Chesapeake Bay Watershed.

31 The proposed WIP modification requires reductions from the Urban sector of 161,194 lb/yr TP and 760,018 lb/yr TN below 2009 levels (see Exhibit 1). Urban nutrient management regulations have the potential to reduce loads by 124,863 lb/yr TP and 466,287 lb/yr TN, leaving 36,331 lb/yr TP and 293,731 lb/yr TN to be removed by retrofits. At an estimated cost of $33,500 $/lb/yr TP and $6,000 $/lb/yr TN, the total cost to perform urban retrofits is [36,631 x $33,500 (TP)] + [293,731 x $6,000 (TN)] = $3.0 Billion.

32 EPA, in their 2009 report titled, "The Next Generation of Tools and Actions to Restore Water Quality in the Chesapeake Bay," estimates the cost of "…retrofits in existing MS4s at about $7.9 billion per year." This equates $462/capita/yr, which is comparable to the Draft WIP and indicates that the high cost of urban retrofits has been anticipated by EPA for some time.

33 US EPA, 2009. The Next Generation of Tools and Actions to Restore Water Quality in the Chesapeake Bay, A Draft Report Fulfilling Section 202a of Executive Order 13508 (Page 23). U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis, MD. (Page 23.)

34 Total Urban sector cost was calculated by multiplying the yearly per-capita cost by the 2009 U.S. Census estimate (http://www.census.gov; last accessed 7/6/2010) population for Virginia within the Bay watershed (6,001,681). The resulting value was then multiplied by 15 years to achieve the total sector cost. Calculations based on 2009 US Census estimate (http://www.census.gov; last accessed 7/6/2010), using Chesapeake Bay Watershed boundary GIS information (ftp://chesapeakebay.net) and the ESRI Virginia County dataset. Where only a portion of a county falls within the watershed, the county population in the watershed is determined by calculating the population of the county (based on the 2009 US Census estimate) times the percent of the county area within the Chesapeake Bay Watershed.

35 Annual per-capita cost was calculated by dividing 7.9 Billion by the Bay-wide watershed population of 17,102,170 (2009 U.S. Census estimate; http://www.census.gov; last accessed 7/6/2010). Calculations based on 2009 US Census estimate (http://www.census.gov; last accessed 7/6/2010), using Chesapeake Bay Watershed boundary GIS information (ftp://chesapeakebay.net) and the ESRI County dataset. Where only a portion of a county falls within the watershed, the county population in the watershed is determined by calculating the population of the county (based on the 2009 US Census estimate) times the percent of the county area within the Chesapeake Bay Watershed.

In addition to providing the lowest cost for tax- and rate-payers in the Commonwealth, the Proposed WIP Modification also provides for a high level of reasonable assurance as described in the sections below.

A. Action Items Required to Achieve the Proposed WIP Modification

1. Upgrade All Significant Discharger Wastewater Treatment Plants

As previously stated, WWTP upgrades are the most cost-effective method of removing nutrients on a cost-per-pound basis (compared with nutrient removal options in other sectors) and provide a very high level of reasonable assurance. This makes upgrading significant discharger wastewater treatment plants to a proposed Tier 4[36] level of treatment (Limits of Technology; TN = 3 mg/l; TP = 0.10 mg/l) a very practical option for the Commonwealth. In addition, an implementation schedule should be established under the next applicable General Permit to allow the necessary plant upgrades to be sequenced over the next 15 years[37] so that, by 2025, every WWTP upgrade has been completed or funded with construction commenced without running into permit compliance issues.

2. Establish Urban Fertilizer Regulations

Another practical and cost-effective option for the Commonwealth is to establish urban fertilizer regulations that include the following nutrient management strategies to reduce TN and TP loadings from home lawns and commercial landscaped areas:

a) Ban on phosphorus use except for newly-planted lawns (1st year) and requirement to use slow-release nitrogen (SRN) formulations only;
b) Ban on sidewalk/driveway applications of fertilizers and lawn clippings;
c) Requirement that fertilizers be applied only by certified applicators in conjunction with soil testing when not using phosphorus-free/SRN formulations on established (older than 1 year) lawns;
d) Implementation of education and public outreach programs that communicate the importance of not exceeding recommended application rates and timing; and
e) Exceptions for organic-based fertilizer formulations that have low TP levels.

Both SRN and phosphorus-free fertilizer are currently available to the public. As an example, Exhibit 6 (Availability of Phosphorus-Free Fertilizer) provides photos documenting the availability SRN and phosphorus–free fertilizer at the Merrifield Garden Center in Gainesville, Virginia, on November 2, 2010[38] at the *same cost* as

[36] As defined by the Chesapeake Bay Program, "*Nutrient Reduction Technology Cost Estimations for Point Sources in the Chesapeake Bay Watershed,*" November 2002.
[37] Rather than the immediate 5-year life of the current General Permit.
[38] In direct comparison of Fairway Formula GreenView fertilizer covering 5,000 square feet per bag. Each formula (29-2-10 Fall fertilizer; 30-0-12 Fall fertilizer with 3/5ths SRN; and 31-0-0 Late Fall fertilizer with 9/10ths SRN) was priced at $39.99.

standard fertilizer. This comparison reinforces the fact that urban nutrient management has the ability to reduce nutrients in an extremely cost effective manner (no cost to less than $10/year[39] for a quarter-acre lot).

3. Expand 5-Year On-Site Pump Out Requirement

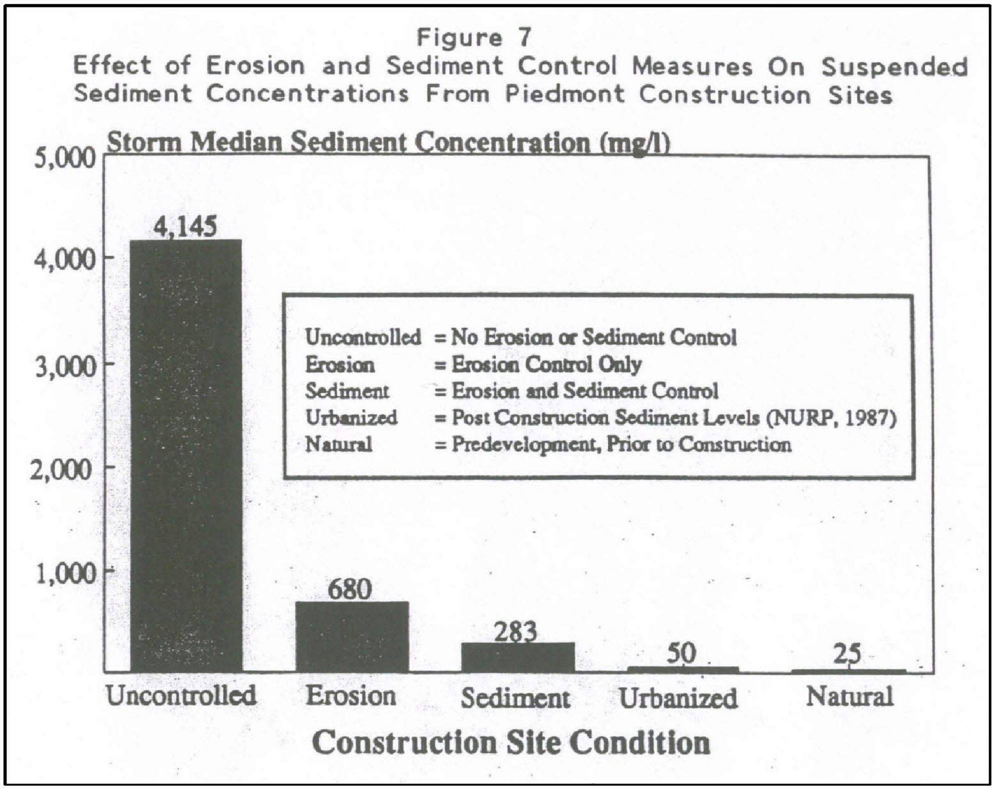
   Expand the 5-year on-site pump out requirement to the entire Chesapeake Bay Watershed (versus only those localities subject to the Chesapeake Bay Act). This will reduce loads from onsite septic users in a cost-effective manner with a high level of reasonable assurance.

4. Improve Erosion and Sediment Control Training and Specifications

   Training and minor specification improvements can more than double the effectiveness of current regulations. This could be facilitated by forming an advisory group to determine the cumulative benefit of minor improvements to training requirements and specifications contained in Virginia's Erosion and Sediment (E&S) Control program. The TMDL model documentation estimates that E&S controls have 40% removal efficiency[40]; however, the report titled, "Performance of Current Sediment Control Measures in Maryland" by the Metropolitan Washington Council of Governments and the Occoquan Watershed Monitoring Laboratory (MWCOG Report) indicates that, with proper installation and maintenance, E&S controls can provide over 90% efficiency[41], as shown in Chart 6, below:

[39] Based on conversations with industry experts and cost comparisons at retail stores in July, 2010. Assuming the approximate cost of straight urea fertilizer is $0.80/pound applied and poly- or sulfur-coated urea fertilizer is $2.30 to $2.70/pound applied (an expensive Slow Release Nitrogen Source), with 1 lb/slow release Nitrogen per 1000 sf/year used and no extra cost for including Phosphorus in the fertilizer. However, as noted above, some stores have no price premium for Phosphorus-free and SRN products.
[40] Chesapeake Bay Model Phase 5 Documentation, Chapter 9 Sediment Simulation (downloaded on October 25, 2010, at: ftp://ftp.chesapeakebay.net/modeling/P5Documentation/SECTION%209.pdf).
[41] 283 mg/l (after erosion and sediment controls) divided by 4,145 mg/l (uncontrolled) = 93.1% removal

Chart 6. Effect of Erosion and Sediment Control Measures on Suspended Sediment Concentrations



Minor changes which should be examined by the advisory group include:

a) Updating the requirements for Responsible Land Disturbers.

   The advisory group should consider requiring Responsible Land Disturbers (RLDs) to first pass Virginia Department of Conservation and Recreation's (DCR's) Basic Erosion and Sediment Control class[42] (discussed below) or be a Professional Engineer (which is currently an option). Anecdotal evidence suggests that E&S controls could achieve much higher efficiencies if installed, inspected, and maintained properly. Therefore, it is critical that most, if not all, land-disturbing professionals be trained in proper E&S control. Currently, professionals (who are not already licensed Professional Engineers) are only required to pass an online test to be certified as a RLD, which does not provide the necessary level of training to properly implement and inspect E&S controls.

b) Privatizing the DCR's E&S training classes, which will allow the RLD requirement discussed above to be practicably implemented.

[42] This requirement should include a two-year grandfathering period to allow sufficient time to train existing RLDs.

Currently, DCR offers three levels of training and instruction for E&S professionals:

- Basic Erosion and Sediment Control in Virginia (16 hours, $80 course fee);
- Erosion and Sediment Control in Virginia for Inspectors (8 hours, $50 course fee); and
- Erosion and Sediment Control in Virginia for Plan Reviewers (16 hours, $80 course fee).

Eight Basic and Inspector classes and three Plan Reviewer classes were held in 2010; certification tests are offered only twice per year at four locations around the Commonwealth. These schedules present hurdles to professional wishing to become certified, especially those from smaller firms who may not have substantial travel budgets available for training.

To facilitate increased class attendance and certification:

- DCR's Basic Erosion and Sediment Control in Virginia class should be privatized to the point that it can be taught by a professional who both holds Plan Inspector certification and has been an active professional in the E&S field for at least one year; and
- Certification tests (subsequent to attending the corresponding class) should be conducted online to increase the number of professionals taking the test while reducing the costs associated with travelling to the test site.

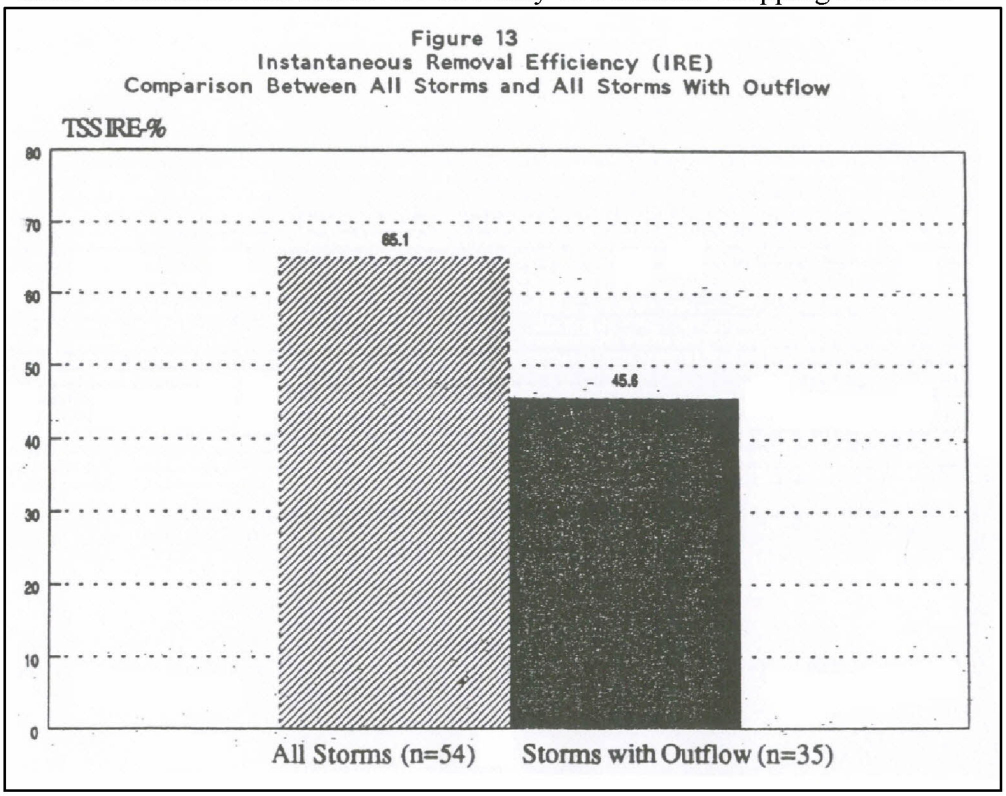
c) Increasing sediment trap size.

The advisory group should consider the effect of increasing the required capacity of sediment-trapping facilities to 202 cy/ac (1.5" watershed-inches) of sediment storage in lieu of the current 134 cy/ac (1" watershed-inch) design standard and requiring that 68 cy/ac (0.5" watershed-inch) of that volume be wet storage. This capacity would allow the facility to capture approximately 1" of runoff on top of the wet storage volume before producing any outflow. The advisory group should consider the cost of such facilities against the potential nutrient and sediment removal. (It should be noted that the Fairfax County Public Facilities Manual already requires 202 cy/ac of capacity for sediment-trapping facilities within Resource Protection Areas.)

The MWCOG Report indicates that "it is important to establish and maintain a generous storage capacity" in sediment traps and basins. The MWCOG Report also notes that, "the presence of standing water has several evident benefits" to sediment removal but that, "the presence of standing water reduces the effective storage capacity." Chart 7[43], below, indicates that the efficiency of sediment-trapping facilities increased from 45.6% to 65.1% when all storms were captured. Therefore, if facilities are sized to capture more storms, their efficiency should also increase.

Additionally, the advisory group should consider the benefit of permitting sediment traps to control drainage from only one acre, rather than three as is currently allowed under Minimum Standard #6. (Fairfax County has required this for many years.)

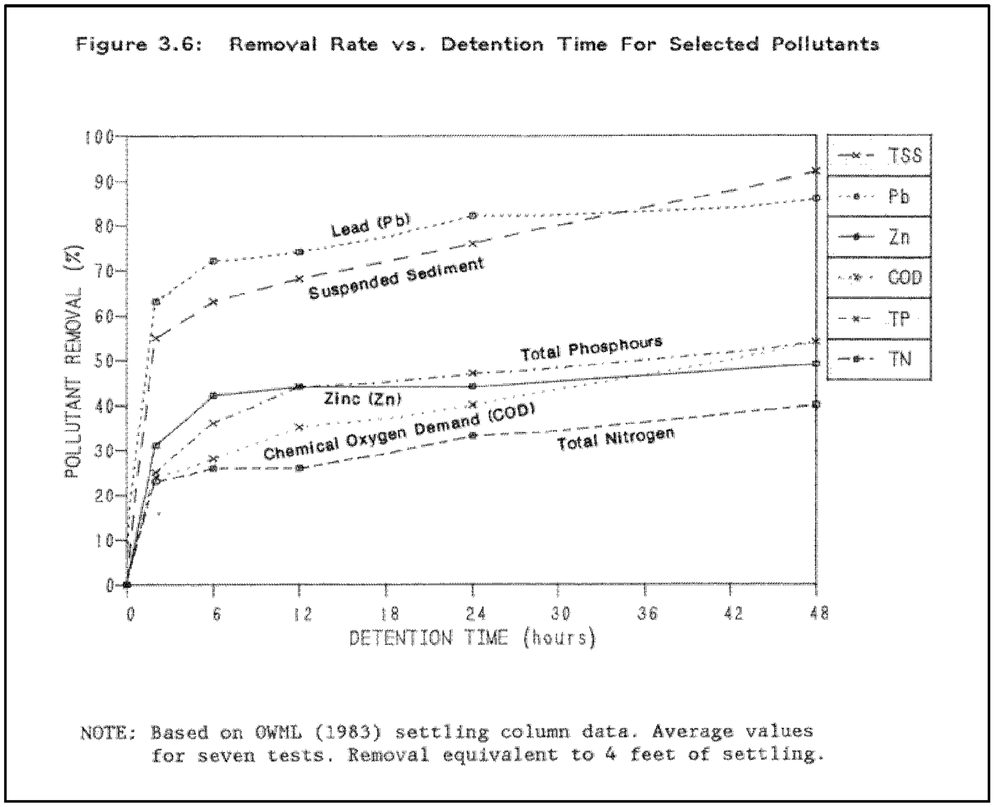
Chart 7. Instantaneous Removal Efficiency of Sediment Trapping Facilities



Increasing the size of sediment-trapping facilities also increases their detention time. As shown in Chart 8[44], below, detention time has a large affect on effluent sediment; 6 hours of detention removes approximately 65% of sediments, while 24 hours of detention removes approximately 75% and 48 hours of detention removes approximately 90% of sediments.

[43] Schueler, T. and J. Lugbill. 1990. *Performance of Current Sediment Control Measures at Maryland Construction Sites.* Occoquan Watershed Monitoring Lab and Metropolitan Washington Council of Governments. Washington, DC. (Page 53.)
[44] Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments. Washington, DC. (Page 3.12.)

Chart 8. Removal Rate Versus Pollutant Removal for Sediment Trapping Facilities



d) Considering the use of skimmers for sediment basin outfalls.

Skimmers (such as the Faircloth Skimmer; see Exhibit 7, Faircloth Skimmers) rise and fall with water levels in sediment basins, thereby removing the cleanest water during the dewatering process, unlike typical static dewatering risers which also remove sediment-laden water from lower in the water column. The advisory group should examine the effect that skimmers may have on reducing effluent sediment from sediment-trapping facilities.

e) Reducing unstabilized soil.

Consider requiring temporary soil stabilization for any sites that will remain dormant for longer than 7 days (rather than 30 as is currently required) and permanent soil stabilization for any sites that will remain dormant for longer than 60 days (rather than one year as is currently required).

The MWCOG Report indicates that, "temporary vegetative stabilization is the single most important factor in reducing downstream suspended sediment (providing a six-fold reduction)." Additionally, "extra efforts need to be made to reestablish vegetative areas that have failed or been damaged by construction equipment or activities."

Chart 6[45], above, indicates that erosion control measures have the potential to reduce downstream sediment loads by 83%, while sediment-trapping measures increase that by only an additional 9%. Therefore, it is imperative that temporary or permanent stabilization be applied rapidly rather than relying on sediment-trapping facilities to re-capture sediment after it has mobilized.

The four considerations above should help construction sites increase their efficiency from 40% to 80% (conservatively), thereby reducing their percentage of the Commonwealth's sediment "pie" from 2.8% to 1.4% (a 50% reduction)[46]. Additionally, TP will be similarly reduced from construction sites (from 1.3% to 0.7%)[47] because it is typically bound to the soil.

5. Establish a "Nutrient Trading Fund"

The Nutrient Trading Exchange (NTE) should be enhanced with a trading fund, which should be set up immediately and can therefore operate before the NTE is finalized in order to generate income for the program as soon as possible. The proposed "Nutrient Trading Fund," which must be approved by the Virginia Board of Soil and Water Conservation, would collect fees both from septic field users without Best Available Technology (BAT) treatment systems and from Virginia Stormwater Management Program (VSMP) permit holders who elect, pursuant to that regulation, to make a payment to offset the portion of TN and TP loadings not treated on site or through other offset mechanisms. This fee shall be established based upon:

a) Avoided sewage fees (excluding "tap" fees) for new septic field users who do not provide TN removal treatment systems as described in Action Item #6, below; or
b) 1.5 times the projected capitalized value[48] of the load[49] removed by upgrading sewage treatment plants[50] from Tier 3 to Tier 4 treatment levels.

[45] Schueler, T. and J. Lugbill. 1990. *Performance of Current Sediment Control Measures at Maryland Construction Sites.* Occoquan Watershed Monitoring Lab and Metropolitan Washington Council of Governments. Washington, DC. (Page 38.)
[46] Based on the Phase 5.3 Chesapeake Bay Model, released 7/21/2010.
[47] Based on the Phase 5.3 Chesapeake Bay Model, released 7/21/2010.
[48] Capital plus operation and maintenance. This value is an estimate of the average WWTP upgrade cost needed to meet the TMDL/WIP.
[49] Needing credits under a VSMP.
[50] In the site's river watershed.

The nutrient Trading Fund can be used to:

a) Fund agricultural BMPs so long as at least 2/3 of the funding covers the costs of BMPs that exceed the draft WIP requirements (and therefore generate credits for the NTE);
b) Fund WWTP flow reduction/conservation/reuse programs which reduce WWTP loads by reducing the effluent volume of a plant[51]; or
c) Retrofit existing septic systems to meet BAT standards (currently, NSF/ANSI standard 245).

6. Allow New Construction with On-Site Sewage Disposal to Exceed NSF/ANSI Standards or Contribute to the Nutrient Trading Fund

   New construction utilizing on-site sewage disposal should:

   a) Provide a wastewater treatment system that meets or exceeds NSF/ANSI standard 245 (which includes a 50% reduction of effluent nitrogen) in conjunction with a shallow-placed drip system if determined to be acceptable by the Virginia Department of Health (VDH) for site conditions; or
   b) Enter into an agreement with DCR that requires the septic field owner to pay quarterly to DCR's "Nutrient Trading Fund" an amount equal to the average sewer bill (during occupancy of the structure with said field) in that river watershed as established annually by the Virginia Board of Soil and Water Conservation.

7. Allow Development Exceeding the Allowable WIP Loads to Contribute to the Nutrient Trading Fund

   Development that does not meet the WIP load requirements[52] with onsite stormwater facilities or other offset mechanisms should pay a fee to the Nutrient Trading Fund described in Action Item #5, above. This will facilitate installing the most cost-effective, nutrient-reducing measures.

The Action Items listed above outline Proposed WIP Modifications which achieve the EPA load allocation goals in a more cost-effective manner than the draft WIP or the EPA backstop. It should be noted that the Proposed WIP Modifications will achieve the EPA load allocation goals at the Commonwealth scale; however, localities and source sectors in some riversheds may need to trade with others to meet the allocations at the local and rivershed level; therefore, maintaining the NTE as proposed is critical.

[51] This reduces the loading rate because the draft WIP limits the effluent concentrations of TN and TP.
[52] For new development, no net increase in TN and TP loads from stormwater above 2025 average nutrient loads per acre from previous uses, and for redevelopment, 20% load reduction.

In conclusion, I would like to again thank you for the opportunity to comment on Virginia's draft WIP. I believe the draft WIP proposed by the Commonwealth could easily be modified into a cost-effective and equitable solution to Virginia's portion of the Bay pollution problem by following the Proposed Sector Allocations and Action Items laid out in Exhibit 1. Please feel free to contact me with any questions or concerns (telephone: 703-679-5602; e-mail: mrolband@wetlandstudies.com).

Sincerely,

WETLAND STUDIES AND SOLUTIONS, INC.

Michael S. Rolband, P.E, P.W.S., P.W.D.
President

List of Exhibits

Exhibit 1: Proposed WIP Modification

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Exhibit 6: Availability of Phosphorus-Free Fertilizer

Exhibit 7: Faircloth Skimmers

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Exhibit 1

Proposed WIP Modification

Exhibit 1: Proposed WIP Modification

Proposed Chesapeake Bay TMDL Phase I Watershed Implementation Plan (WIP) Allocations and Action Strategies for the Commonwealth of Virginia Response to Public Comment Request

Table 1, below, provides a proposed WIP allocation for Total Nitrogen (TN) and Total Phosphorous (TP) by sector, as well as a comparison of the proposed loads to current loads, the September 2010 Draft WIP, and the Stakeholder Advisory Group's (SAG) recommendation:

Table 1. Pollutant Loading Comparison

Total Nitrogen TMDL Allocations (Pounds/Year)

Source Data	2009 [1]	WIP Sept. 2010 [2]	SAG [3]	**Proposed WIP**
Agriculture	21,840,226	16,391,000	16,577,610	17,985,000
Urban Runoff	6,868,018	3,915,000	6,107,925	6,108,000
Wastewater	20,028,080	20,394,000	19,471,849	12,082,000 [4]
On-Site	2,631,823	1,922,000	2,673,994	2,674,000
Forest	13,756,189	13,939,000	13,951,338	13,939,000
Non-Tidal Dep.	604,005	612,000	611,967	612,000
Total	65,728,341	57,173,000	59,394,683	53,400,000

Total Phosphorous TMDL Allocations (Pounds/Year)

Source Data	2009 [1]	WIP Sept. 2010 [2]	SAG [3]	**Proposed WIP**
Agriculture	3,065,034	2,146,000	2,200,340	2,533,000
Urban Runoff	1,200,194	380,000	1,038,535	1,039,000
Wastewater	1,728,923	1,832,000	1,828,174	690,000 [4]
On-Site	-	-	-	-
Forest	1,089,197	1,090,000	1,090,986	1,090,000
Non-Tidal Dep.	56,755	58,000	57,421	58,000
Total	7,140,103	5,506,000	6,215,456	5,410,000

[1] *SAG Handout, 6/16/2010*
[2] *Public Review Draft of WIP, September 2010*
[3] *SAG Handout, 8/24/2010*
[4] *Load Reduction achieved by reducing significant WTP effluent concentrations to: TN = 3 mg/L; TP = 0.10 mg/L (except UOSA due to sediment)*
Wastewater (TN lb/yr) = WIP Sept 2010 - [Current WLA – Load Reduction]
= 20,394,000 - 8,312,412 = 12,081,588 TN lb/yr
Wastewater (TP lb/yr) = WIP Sept 2010 - [Current WLA – Load Reduction]
=1,832,000 - 1,141,825 = 690,175 TP lb/yr

Achievement of these proposed WIP allocations can be obtained by modifying the current WIP with the following actions:

1. **Upgrade all Significant Discharger Wastewater Treatment Plants**

   Upgrade all Significant Discharger Wastewater Treatment Plants (WTP) to the Tier 4[1] level of treatment (TN = 3 mg/l; TP = 0.10 mg/l). Establish an Implementation Schedule such that the necessary plant upgrades would be sequenced over the next 15 years so that, by 2025, every WTP upgrade has been completed or funded with construction commenced.

2. **Establish Urban Fertilizer Regulations**

   Establish urban fertilizer regulations that include the following nutrient management strategies to reduce TN and TP loadings from home lawns and commercial landscaped areas:
   a) Ban on phosphorus use except for newly-planted lawns (1st year) and requirement to use slow-release nitrogen (SRN) formulations only;
   b) Ban on sidewalk/driveway applications of fertilizers and lawn clippings;
   c) Requirement that fertilizers be applied only by certified applicators in conjunction with soil testing when not using phosphorus-free/SRN formulations on established (older than 1 year) lawns;
   d) Implementation of education and public outreach programs that communicate the importance of not exceeding recommended application rates and timing; and
   e) Exceptions for organic-based fertilizer formulations that have low TP levels.

3. **Expand 5-Year On-Site Septic Pump Out Requirement**

   Expand the 5-year on-site septic pump out requirement to the entire watershed (vs. only those localities subject to the Chesapeake Bay Act).

4. **Improve Erosion and Sediment Control Training and Certification**

   Improve erosion and sediment controls on construction sites through a combination of improved training and increased local inspections and the following strategies:
   a) Requirement that every "Responsible Land Disturber" either pass DCR's "Basic Erosion and Sediment Control in Virginia Course," or be a Professional Engineer (P.E.); and
   b) Improvements to the timing of disturbed area seeding/mulching and sediment trap/basin sizing.

5. **Establish a "Nutrient Trading Fund"**

   Establish a "Nutrient Trading Fund," approved by the Virginia Board of Soil and Water Conservation, that collects fees from septic fields users without Best Available Technology (BAT) treatment systems and Virginia Stormwater Management Program (VSMP) permit holders who elect, pursuant to that regulation, to make a payment to

[1] As defined by the Chesapeake Bay Program, "*Nutrient Reduction Technology Cost Estimations for Point Sources in the Chesapeake Bay Watershed,*" November 2002.

offset the portion of TN and TP loadings not treated on site or through other offset mechanisms. This fee shall be established based upon:

a) avoided sewage fees (excluding "tap" fees) for new and existing septic field users who do not provide TN removal treatment systems as described in *Action Item #6*, below; or
b) 1.5 times the projected capitalized value[2] of the load[3] removed by upgrading sewage treatment plants[4] from Tier 3 to Tier 4 treatment levels.

The nutrient Trading Fund can be used to:

a) Fund agricultural BMPs so long as at least 2/3 of the funding covers the costs of BMPs that exceed the WIP requirements;
b) Fund WTP flow reduction/conservation/reuse programs which reduce WTP loads by reducing the effluent volume of a plant[5]; or
c) Retrofit existing septic systems with BAT (currently systems that meet NSF/ANSI standard 245).

6. **Allow New Construction with On-Site Sewage Disposal to Exceed NSF/ANSI Standards or Contribute to the Nutrient Trading Fund**

Require new construction utilizing on-site sewage disposal to:

a) Provide a wastewater treatment system that meets or exceeds NSF/ANSI standard 245 (which includes a 50% reduction of influent nitrogen) in conjunction with a shallow-placed drip system if determined to be acceptable by the Virginia Department of Health (VDH) for site conditions, or
b) Enter into an agreement with DCR that requires the septic field owner to pay quarterly to DCR's "Nutrient Trading Fund" an amount equal to the average sewer bill (during occupancy of the structure with said field) in that river watershed as established annually by the Virginia Board of Soil and Water Conservation.

7. **Allow Development Exceeding the Allowable WIP Loads to Contribute to the Nutrient Trading Fund**

Require development that does not meet the WIP load requirements[6] with onsite systems or other offset mechanisms to pay a fee to the Nutrient Trading Fund described in *Action Item #5*.

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[2] Capital plus operation and maintenance. This value is an estimate of the average WTP upgrade cost needed to meet the TMDL/WIP.
[3] Needing credits under a VSMP.
[4] In the site's river watershed.
[5] This reduces the loading rate because the WIP limits the effluent concentrations of TN and TP.
[6] For new development, no net increase in TN and TP loads from stormwater above 2025 average nutrient loads per acre from previous uses, and for redevelopment, 20% load reduction.

Exhibit 2

2.1 Cost-Effectiveness of Pollutant Removal Options for the Urban Sector Population

2.2 Analysis of Current WLAs Versus LOT Estimates for Significant Dischargers' Delivered Loads by Basin

2.1 Cost-Effectiveness of Pollutant Removal Options for the Urban Sector Population

Exhibit 2.1: Cost Effectiveness of Pollutant Removal Options for the Urban Sector Population

A. Capital Cost of Significant Municipal Upgrades

1. Unit Cost Estimate

The Chesapeake Bay Program report[1] cites costs related to upgrading Significant WWTP's to Tier 4 (the Limit of Technology, LOT), as well as annual operation and maintenance (O&M) costs. Based on the data in this report, the following costs can be anticipated:

		TN	TP
• Capital Cost[2]	-	$691,203,142	$595,432,918
• Approximate O&M Costs[3]	-	$11,543,148/yr	$52,293,664/yr
Present Worth	-	$199,604,500	$904,263,779
• Pollutant Removal[4]	-	3,536,099 lbs/yr	551,509 lbs/yr
• Removal Cost Rate			
Capital Cost Rate	-	$195.47/lb-yr	$1,079.64/lb-yr
O&M Cost Rate	-	$56.45/lb-yr	$1,639.62/lb-yr

The above Removal Cost Rate is reflective of data presented in the 2002 Chesapeake Bay Program report[1].

2. Cost to Upgrade to LOT (3.0 mg/l TN and 0.10 mg/l TP)

To obtain an order of magnitude cost estimate of upgrading significant municipal WWTP's in Virginia from current (2009) levels of treatment to the LOT, the estimated

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[1] Chesapeake Bay Program, "Nutrient Reduction Technology Cost Estimations for Point Sources in the Chesapeake Bay Watershed," November, 2002.

[2] Capital costs to upgrade WWTP's in VA taken from Table X-A for TN = $475,053,706 (Δ, Tier 3 to Tier 4, Page 105) and X-B for TP = $409,232,246 (Δ, Tier 3 to Tier 4, Page 115). Scaling up based on the ENR Construction Cost Index (20 city average): January 2000: ----- 6130 October 2010:------ 8921 Resulting Index = 8921/6130 = 1.455
Capital Costs = $199,138,981 for TN and $595,432,918 for TP

[3] O&M Costs taken from Table X-A for TN (Page 105) and X-B for TP (Page 115) to operate WWTP's at Tier 4 in VA. Present Worth calculation assumes 30 year operating life and a rate of 4%.

[4] Pollutant Removal for all VA Significant Municipal WWTP's calculated from the Chesapeake Bay Program report as follows: The percentage of total flow attributed to significant WWTP's was calculated from Table X-C (page 116) = 871.95/1,164.44 = 0.75. This percentage was then applied to the Δ loading rates between Tier 3 and Tier 4 provided in Tables IX-B (page 71) and IX-E (page 72) for TN and TP, respectively. The resulting Pollutant Removal: TN = (12,784,164 – 8,069,366) * 0.75 = 3,536,099 lbs/yr and TP = (1,031,954 – 296,609) * 0.75 = 551,509 lbs/yr.

Removal Cost Rate (calculated above) was applied to the load reductions projected to be achieved through the upgrade:

			TN	TP
• Pollutant Removal[5]		-	8,312,412 lbs/yr	1,141,825 lbs/yr
• Total Projected Cost				
	Capital Cost	-	$1,624,827,174	$1,232,759,943
	O&M Cost	-	$469,983,775	$1,872,159,107

B. Urban Retrofits

1. EPA Backstop

EPA has commented on the Virginia draft Watershed Implementation Plan (draft WIP) and recommends that 50% of urban MS4 lands and 25% of unregulated land meet "aggressive performance standards" through retrofit/redevelopment. While it is unclear exactly how many impervious acres in Virginia would be classified as "urban MS4 and unregulated lands", it was assumed that 50% of the total number of impervious acres in the urban, high density category (in the Chesapeake Bay Model, 2009Progress[6]) and 25% of the impervious acres in the low density category would be subject to this requirement. This equates to 50% of 150,340 acres and 25% of 116,098 acres, respectively, for a total of 104,195 acres. Computing the necessary costs to retrofit these urban lands:

Capital Cost - 104,195 imp ac * $102,520/imp ac[7] = $10,682,071,400

- Approximate O&M Costs[8] - $1,786,969,114
- Total Cost - $12,469,040,514

[5] WSSI spreadsheet using Current Design Flows for all VA Significant Municipal WWTP's provided by Russ Baxter (DEQ) via email 9/21/2010 and effluent concentrations of 3.0 mg/l-TN and 0.10 mg/l-TP (except UOSA which remained at 8.0 mg/l-TN). These Pollutant Removal numbers represent the Δ between the calculated load and the current WLA.

[6] Phase 5.3 Chesapeake Bay Model (Released 7/21/2010).

[7] Center for Watershed Protection, Urban Subwatershed Restoration Manual Series, Manual 3, Urban Stormwater Retrofit Practices, Version 1.0, Appendix E, Table E.1, 2007. The average cost is listed as $88,000/impervious acre treated. Scaling up based on the ENR Construction Cost Index (20 city average):
January 2006: ----- 7660 October 2010:------ 8921 Resulting Index = 8921/6130 = 1.165 CC = $102,520

[8] Low Impact Development Supplement to the Northern Virginia BMP Handbook, October 2007. Annual maintenance costs for various practices (to treat ½ ac impervious) are listed as:

Permeable Pavement	- $580
Bioretention Area	- $1,560
Filtration Devices	- $1,100
Vegetated Swale	- $430

For this analysis, assumed an annual cost of $450 per ½ ac (i.e., $900/ac) and a treatment area = 104,195 imp. ac. Resulting annual cost = $93,775,500/yr. Scaling up based on the ENR Construction Cost Index (20 city average):
November 2007: ------ 8092 October 2010:------ 8921 Resulting Index = 8921/8092 = 1.102
Annual Maintenance Cost = $103,340,601. Assuming a 30 year life and a rate of 4%, Present Worth = $1,786,969,114.

- Pollutant Removal (assuming 85% removal efficiency – an extremely optimistic assumption)

  - TN = 104,195 ac * 11.8 lbs/ac-yr * 85% RR = 1,045,076 lbs/yr
  - TP = 104,195 ac * 2.1 lbs/ac-yr * 85% RR = 185,988 lbs/yr

Removal Cost (assuming 50/50 allocation of Total Costs between TN and TP)[9]

  - TN = $5,966/lb-yr
  - TP = $33,521/lb-yr

2. Draft WIP Level for Urban

The September 2010 Public Review Draft of the draft WIP does not provide specific details as to exactly what acreages of urban retrofit is needed and what techniques are desired. However, it can be calculated how many lbs of TN and TP must be removed by urban retrofit by subtracting the urban sector allocation in the draft WIP from the 2009 Progress loadings. That reduction, multiplied by the unit costs described above yields the following order of magnitude estimates:

Pollutant/Source	*2009[10] (lbs/yr)*	*Draft WIP[11] (lbs/yr)*	*Removal (lbs/yr)*	*Capital Cost ($ Billion)*	*O&M Cost ($ Billion)*	*Total Cost ($ Billion)*
TN – Urban Runoff	6,868,018	3,915,000	2,953,000	15.2	2.5	17.7
TP – Urban Runoff	1,200,194	380,000	820,000	23.5	4.0	27.5

3. Septic Field Upgrade

The same type of calculation can be made to determine the cost of upgrading on-site septic systems to the draft WIP level. The unit cost for septic system TN removal is computed as follows:

- 8.92 lbs N/person/yr (draft WIP, page 82)
- $12,800/system to upgrade to BAT, 50% removal, (MD draft WIP, page 2-7)
- Assuming 4 people/system
- Removal Cost = [$12,800/(4* 8.92 * 50%)] = $717/lb-TN

The total TN Removed (Δ, 2009 Progress to draft WIP) = 709,823 lbs-TN/yr
The resulting Total Capital Cost = $717lb-TN * 709,823 lbs-TN/yr = $508,943,091

C. Urban Fertilizer Management

[9] Unlike WWTP's, BMP's are not designed to remove a particular pollutant.
[10] SAG Handout, 6/16/2010
[11] Public Review Draft of WIP, September 2010

Another option for achieving a significant reduction in TN and TP loads is through legislative changes regarding the application and chemical make-up of lawn and landscape fertilizer. Specifically, by establishing urban fertilizer regulations that include the following nutrient management strategies to reduce TN and TP loadings from home lawns and commercial landscaped areas:

a) Ban on phosphorus use except for newly-planted lawns (1st year) and requirement to use slow-release nitrogen (SRN) formulations only;
b) Ban on sidewalk/driveway applications of fertilizers and lawn clippings;
c) Requirement that fertilizers be applied only by certified applicators in conjunction with soil testing when not using phosphorus-free/SRN formulations on established (older than 1 year) lawns;
d) Implementation of education and public outreach programs that communicate the importance of not exceeding recommended application rates and timing; and
e) Exceptions for organic-based fertilizer formulations that have low TP levels.

Pursuant to a literature review entitled *"Effects of Fertilizer Management Practices on Urban Runoff Quality"* [12], the resulting estimated pollutant reductions that can be expected are 25-50% for TP and 10-20% for TN. For the purposes of this analysis, it was assumed the lower end of each range would be achieved. The single biggest cost premium would be in the increase in cost to change fertilizer formulations to provide slow-release nitrogen. This cost is estimated to be $1.90/lb[13], which, for a 10% reduction, would equate to $19.00/lb-TN removed. Note there is no additional cost for the 25% reduction in TP load (i.e. it is our understanding that eliminating TP from fertilizer has no significant cost implications in volume applications as long as existing supplies are allowed to be used up during a transition period). The resulting pollutant removal would be[14]:

- TN = 4,662,873 lbs/yr * 10% = 466,287 lbs-TN/yr

- TP = 499,451 lbs/yr * 25% = 124,863 lbs-TP/yr

D. Conclusion

The above cost and loading calculations are summarized in the following table to provide an order of magnitude comparison of the various removal technologies under consideration:

[12] Daniels, W,. Goatley, M., Maquire, R., Sample, D., 2010. Effects of Fertilizer Management Practices on Urban Runoff Quality. Virginia Polytechnic Institute and State University and Occoquan Watershed Monitoring Lab.

[13] Based on conversations with industry experts and recent cost comparisons at retail stores. Assuming the approximate cost of straight urea fertilizer is $0.80/pound applied and poly- or sulfur-coated urea fertilizer is $2.30 to $2.70/pound applied (an expensive Slow Release Nitrogen Source), with 1 lb/slow release Nitrogen per 1,000 sf/year used (Δ = $2.70 - $0.80 = $1.90/lb) and no extra cost for including Phosphorus in the fertilizer. It is very possible that market demand for such a product would reduce costs below this amount and lower cost formulations are available.

[14] Based on loadings from Phase 5.3 Chesapeake Bay Model (Released 7/21/2010) from pervious surfaces in the urban category.

Proposed Options	*Capital Cost ($ Billion)*	*O&M Cost (Present Worth, $ Billion)*	*Total Cost ($ Billion)*	*Total Removed (Million lbs/yr)*		*Removal Cost* ($/lb-yr)*	
				TN	*TP*	*TN*	*TP*
WWTP - EPA Backstop	1.7	1.2	2.9	5.70	0.54	250	2,700
WWTP - LOT	2.9	2.3	5.2	8.31	1.14	250	2,700
WWTP - Potomac Embayment	2.6	1.9	4.5	8.31	0.87	250	2,700
WWTP – draft WIP	0	0	0	0	0	N/A	N/A
Urban Retrofit - EPA Backstop	10.7	1.8	12.5	1.34	0.24	6,000	33,500
Urban Retrofit - draft WIP	38.7	6.5	45.2	2.95	0.82	6,000	33,500
Septic Field Upgrades - draft WIP	0.5	?	0.5	0.71	-	720	N/A
Urban Fertilizer Management	N/A	N/A	N/A	0.47	0.12	19	0

** Urban Retrofit - 50/50 cost allocation between TN/TP*
- Total Area = 50% of high density impervious and 25% of low density impervious

From the above, it is evident that upgrading the significant WWTP's would be far more cost effective in helping to achieve the stated goals than retrofitting impervious areas or upgrading on-site septic systems. Besides this obvious financial benefit, it is also substantially more practical to upgrade the point discharges represented by the WWTP's than to attempt to retrofit thousands of developed acres with BMP's that have unreliable removal efficiencies that would make assessing their effectiveness very difficult. Lastly, simply managing the content and application of fertilizer in urban areas can be expected to reduce the loadings of TN and TP from pervious urban areas by an estimated 10 and 25%, respectively, at very low cost.

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2.2 Analysis of Current WLAs Versus LOT Estimates for Significant Dischargers' Delivered Loads by Basin

Current WLAs vs LOT Estimates for Significant Dischargers' Delivered Loads by Basin

Current WLAs for Significant Dischargers' Delivered Loads by Basin

Basin	Design Flow (MGD) [1]	Delivered (lbs/yr) [1,2,3] TN WLA	Delivered (lbs/yr) [1,2,3] TP WLA
Shenandoah-Potomac	414.46	3,286,494	195,326
Rappahannock	50.89	468,644	41,684
York	113.14	957,180	157,297
James	683.34	13,564,321	1,088,480
Eastern Shore	2.70	40,506	2,466
TOTALS:	**1,264.53**	**18,317,145**	**1,485,253**

LOT for Significant Dischargers' Delivered Loads by Basin

TN Concentration =	**3.00**	**mg/L**
TP Concentration =	**0.10**	**mg/L**

Basin	Design Flow (MGD) [1]	Delivered (lbs/yr) [2,3] TN WLA	Delivered (lbs/yr) [2,3] TP WLA
Shenandoah-Potomac [4]	414.46	2,998,664	99,988
Rappahannock	50.89	351,480	13,895
York	113.14	974,219	32,389
James	683.34	5,655,701	196,335
Eastern Shore	2.70	24,670	821
TOTALS:	**1,264.53**	**10,004,733**	**343,428**

Difference between Current WLAs and LOT WLAs for Significant Dischargers' Delivered Loads by Basin

Basin	Design Flow (MGD) [1]	Δ (Current WLA - LOT) Delivered (lbs/yr) [1,2,3] TN WLA	Δ (Current WLA - LOT) Delivered (lbs/yr) [1,2,3] TP WLA
Shenandoah-Potomac [4]	No change	287,831	95,338
Rappahannock	No change	117,165	27,789
York	No change	-17,039	124,908
James	No change	7,908,620	892,145
Eastern Shore	No change	15,836	1,645
TOTALS:	No change	**8,312,412**	**1,141,825**

1. Current Design Flows and Waste Load Allocations (WLA) provided by Russ Baxter (DEQ - Chesapeake Bay Program) via email 9/21/2010

*2 lb/yr = MGD * mg/L * 2.2046 lb/kg * 3.785 L/gal * 365 days/yr*

*3 Delivered WLA lb/yr = Discharged WLA (lb/yr) * Delivery Factor*

4 UOSA - Centreville Plant concentrations remain at TN = 8.0 mg/L and TP = 0.1 mg/L

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LOT WLA Worksheet
Shenandoah-Potomac River Basin **TN Concentration = 3.00 mg/L**
TP Concentration = 0.10 mg/L

Discharger Name	VPDES Permit No.	Design Flow (MGD)	2025 TN Conc. (mg/l)	**Discharged** TN Waste Load Allocation (lbs/yr) [1]	TP Conc. (mg/l)	**Discharged** TP Waste Load Allocation (lbs/yr) [1]	TSS Conc. (mg/l)	**Discharged** TSS Waste Load Allocation (lbs/yr) [1]	TN Delivery Factor	TP Delivery Factor	TSS Delivery Factor	**Delivered** TN Waste Load Allocation (lbs/yr) [2]	**Delivered** TN Waste Load Allocation (lbs/yr) [2]	**Delivered** TN Waste Load Allocation (lbs/yr) [2]
US NSWC-Dahlgren WWTF	VA0021067	0.72	3.00	6,578	0.10	219	30.00	65,784	1.00	1.00	1.00	6,578	219	65,784
Colonial Beach STP	VA0026409	2.00	3.00	18,273	0.10	609	30.00	182,734	1.00	1.00	1.00	18,273	609	182,734
Dahlgren WWTF	VA0026514	1.00	3.00	9,137	0.10	305	30.00	91,367	1.00	1.00	1.00	9,137	305	91,367
Purkins Corner STP	VA0070106	0.12	3.00	1,096	0.10	37	30.00	10,964	1.00	1.00	1.00	1,096	37	10,964
Quantico WWTF	VA0028363	2.20	3.00	20,101	0.10	670	30.00	201,007	1.00	1.00	1.00	20,101	670	201,007
Aquia WWTF	VA0060968	8.00	3.00	73,093	0.10	2,436	30.00	730,934	1.00	1.00	1.00	73,093	2,436	730,934
Fairview Beach	VA0092134	0.20	3.00	1,827	0.10	61	30.00	18,273	1.00	1.00	1.00	1,827	61	18,273
Blue Plains (VA Share)	DC0021199	47.73	3.00	436,094	0.10	14,536	7.00	1,017,552	1.00	1.00	1.00	436,094	14,536	1,017,552
Pilgrims Pride - Alma	VA0001961	1.00	3.00	9,137	0.10	305	30.00	91,367	0.32	0.53	0.69	2,962	161	63,340
INVISTA - Waynesboro (Outfall 101)	VA0002160	1.44	3.00	13,157	0.10	439	30.00	131,568	0.13	0.53	0.69	1,728	232	91,210
Merck - Stonewall WWTP (Outfall 101)	VA0002178	1.20	3.00	10,964	0.10	365	30.00	109,640	0.32	0.53	0.69	3,555	193	76,008
VA Poultry Growers - Hinton	VA0002313	1.50	3.00	13,705	0.10	457	30.00	137,050	0.12	0.53	0.69	1,688	242	95,011
Strasburg STP	VA0020311	0.98	3.00	8,954	0.10	298	30.00	89,539	0.42	0.53	0.69	3,789	158	62,074
Berryville STP	VA0020532	0.70	3.00	6,396	0.10	213	30.00	63,957	0.63	0.53	0.69	4,027	113	44,338
Weyers Cave STP	VA0022349	0.50	3.00	4,568	0.10	152	30.00	45,683	0.23	0.53	0.69	1,070	80	31,670
Basham Simms WWTF	VA0022802	1.50	3.00	13,705	0.10	457	30.00	137,050	0.71	0.53	0.69	9,682	242	95,011
New Market STP	VA0022853	0.50	3.00	4,568	0.10	152	30.00	45,683	0.19	0.53	0.69	857	80	31,670
Massanutten PSA STP	VA0024732	1.50	3.00	13,705	0.10	457	30.00	137,050	0.32	0.53	0.69	4,443	242	95,011
Waynesboro STP	VA0025151	4.00	3.00	36,547	0.10	1,218	30.00	365,467	0.13	0.53	0.69	4,801	645	253,361
Fishersville Regional STP	VA0025291	4.00	3.00	36,547	0.10	1,218	30.00	365,467	0.09	0.53	0.69	3,424	645	253,361
Round Hill Town WWTF	VA0026212	0.75	3.00	6,853	0.10	228	30.00	68,525	0.71	0.53	0.69	4,841	121	47,505
Mt. Jackson STP	VA0026441	0.70	3.00	6,396	0.10	213	30.00	63,957	0.34	0.53	0.69	2,170	113	44,338
Woodstock STP	VA0026468	2.00	3.00	18,273	0.10	609	30.00	182,734	0.34	0.53	0.69	6,199	322	126,681
Stoney Creek SD STP	VA0028380	0.60	3.00	5,482	0.10	183	30.00	54,820	0.34	0.53	0.69	1,860	97	38,004
North River WWTF	VA0060640	20.80	3.00	190,043	0.10	6,335	30.00	1,900,429	0.22	0.53	0.69	41,840	3,352	1,317,480
Luray STP	VA0062642	1.60	3.00	14,619	0.10	487	30.00	146,187	0.42	0.53	0.69	6,142	258	101,345
Front Royal STP	VA0062812	4.00	3.00	36,547	0.10	1,218	30.00	365,467	0.61	0.53	0.69	22,261	645	253,361
Middle River Regional STP	VA0064793	6.80	3.00	62,129	0.10	2,071	30.00	621,294	0.09	0.53	0.69	5,821	1,096	430,714
Opequon WRF	VA0065552	8.40	3.00	76,748	0.10	2,558	30.00	767,481	0.24	0.53	0.69	18,208	1,354	532,059
Stuarts Draft WWTP	VA0066877	4.00	3.00	36,547	0.10	1,218	30.00	365,467	0.05	0.53	0.69	1,859	645	253,361
MillerCoors	VA0073245	4.50	3.00	41,115	0.10	1,371	30.00	411,151	0.32	0.53	0.69	13,330	726	285,032
Parkins Mill STP	VA0075191	5.00	3.00	45,683	0.10	1,523	30.00	456,834	0.24	0.53	0.69	10,838	806	316,702
Georges Chicken LLC	VA0077402	1.70	3.00	15,532	0.10	518	30.00	155,324	0.34	0.53	0.69	5,269	274	107,679
Broadway Regional (SIL)	VA0090263	1.92	3.00	17,542	0.10	585	30.00	175,424	0.19	0.53	0.69	3,293	310	121,613
North Fork Regional WWTP	VA0090328	0.75	3.00	6,853	0.10	228	30.00	68,525	0.34	0.53	0.69	2,325	121	47,505
Broad Run WRF	VA0091383	11.00	3.00	100,503	0.10	3,350	30.00	1,005,035	0.89	0.53	0.69	89,180	1,773	696,744
Leesburg WPCF	VA0092282	10.00	3.00	91,367	0.10	3,046	30.00	913,668	0.79	0.53	0.69	72,256	1,612	633,404
Vint Hill WWTF	VA0020460	0.95	3.00	8,680	0.10	289	30.00	86,798	0.05	0.17	0.14	436	50	12,069
Dale Serv. Corp. - Section 8 WWTF	VA0024678	4.60	3.00	42,029	0.10	1,401	30.00	420,287	1.00	1.00	1.00	42,029	1,401	420,287
Dale Serv. Corp. - Section 1 WWTF	VA0024724	4.60	3.00	42,029	0.10	1,401	30.00	420,287	1.00	1.00	1.00	42,029	1,401	420,287
UOSA - Centreville [3]	VA0024988	54.00	8.00	1,315,682	0.10	16,446	30.00	4,933,807	0.23	0.32	0.37	307,964	5,266	1,823,785
H L Mooney WWTF	VA0025101	24.00	3.00	219,280	0.10	7,309	30.00	2,192,803	1.00	1.00	1.00	219,280	7,309	2,192,803
Arlington County Water PCF	VA0025143	40.00	3.00	365,467	0.10	12,182	30.00	3,654,672	1.00	1.00	1.00	365,467	12,182	3,654,672
Alexandria SA WWTF	VA0025160	54.00	3.00	493,381	0.10	16,446	30.00	4,933,807	1.00	1.00	1.00	493,381	16,446	4,933,807
Noman M Cole Jr PCF	VA0025364	67.00	3.00	612,158	0.10	20,405	30.00	6,121,576	1.00	1.00	1.00	612,158	20,405	6,121,576
TOTALS:		414.46		4,609,090		126,224		34,524,499				2,998,664	99,988	28,443,495

[1] *lb/yr = MGD * mg/L * 2.2046 lb/kg * 3.785 L/gal * 365 days/yr*

[2] *Delivered WLA lb/yr = Discharged WLA (lb/yr) * Delivery Factor*

[3] *For proper operations, UOSA - Centreville plant remains at TN = 8.0 mg/L and TP = 0.1 mg/L*

LOT WLA Worksheet
Rappahannock River Basin **TN Concentration = 3.00 mg/L**
TP Concentration = 0.10 mg/L

Discharger Name	VPDES Permit No.	Design Flow (MGD)	TN Conc. (mg/l)	**Discharged** TN Waste Load Allocation (lbs/yr) [1]	TP Conc. (mg/l)	**Discharged** TP Waste Load Allocation (lbs/yr) [1]	TSS Conc. (mg/l)	**Discharged** TSS Waste Load Allocation (lbs/yr) [1]	TN Delivery Factor	TP Delivery Factor	TSS Delivery Factor	**Delivered** TN **Waste Load Allocation (lbs/yr)** [2]	**Delivered** TN **Waste Load Allocation (lbs/yr)** [2]	**Delivered** TN **Waste Load Allocation (lbs/yr)** [2]
Omega Protein - Reedville	VA0003867	3.21	3.00	15,910	0.10	530	30.00	159,098	1.00	1.00	1.00	15,910	530	159,098
Kilmarnock WTP	VA0020788	0.50	3.00	4,568	0.10	152	30.00	45,683	1.00	1.00	1.00	4,568	152	45,683
Reedville Sanitary District	VA0060712	0.20	3.00	1,827	0.10	61	30.00	18,273	1.00	1.00	1.00	1,827	61	18,273
Haynesville CC WWTP	VA0023469	0.23	3.00	2,101	0.10	70	30.00	21,014	1.00	1.00	1.00	2,101	70	21,014
HRSD-Urbanna WWTP	VA0026263	0.10	3.00	914	0.10	30	30.00	9,137	1.00	1.00	1.00	914	30	9,137
Warsaw STP	VA0026891	0.30	3.00	2,741	0.10	91	30.00	27,410	1.00	1.00	1.00	2,741	91	27,410
Tappahannock WWTP	VA0071471	0.80	3.00	7,309	0.10	244	30.00	73,093	1.00	1.00	1.00	7,309	244	73,093
Westmoreland-Montross WWTP	VA0072729	0.13	3.00	1,188	0.10	40	30.00	11,878	0.74	0.97	1.00	880	38	11,878
Warrenton STP	VA0021172	2.50	3.00	22,842	0.10	761	30.00	228,417	0.19	0.78	1.00	4,294	595	228,417
Orange STP	VA0021385	3.00	3.00	27,410	0.10	914	30.00	274,100	0.28	0.78	1.00	7,806	714	274,100
Fredericksburg WWTF	VA0025127	4.50	3.00	41,115	0.10	1,371	30.00	411,151	1.00	1.00	1.00	41,115	1,371	411,151
Spotsylvania Co-Massaponax WWTF	VA0025658	8.00	3.00	73,093	0.10	2,436	30.00	730,934	1.00	1.00	1.00	73,093	2,436	730,934
FCW&SA-Marshall WWTP	VA0031763	0.64	3.00	5,847	0.10	195	30.00	58,475	0.19	0.78	1.00	1,099	152	58,475
US Army -Ft. A.P. Hill WWTP	VA0032034	0.53	3.00	4,842	0.10	161	30.00	48,424	1.00	1.00	1.00	4,842	161	48,424
Culpeper WWTP	VA0061590	6.00	3.00	54,820	0.10	1,827	30.00	548,201	0.49	0.78	1.00	26,953	1,429	548,201
Spotsylvania Co-FMC WWTF	VA0068110	5.40	3.00	49,338	0.10	1,645	30.00	493,381	1.00	1.00	1.00	49,338	1,645	493,381
Little Falls Run WWTF	VA0076392	8.00	3.00	73,093	0.10	2,436	30.00	730,934	1.00	1.00	1.00	73,093	2,436	730,934
FCW&SA-Remington WWTP (3)	VA0076805	2.50	3.00	22,842	0.10	761	30.00	228,417	0.49	0.78	1.00	11,230	595	228,417
Clevengers Village STP (4)	VA0080527	0.90	3.00	8,223	0.10	274	30.00	82,230	0.19	0.78	1.00	1,546	214	82,230
RSA-Wilderness WWTP	VA0083411	1.25	3.00	11,421	0.10	381	30.00	114,209	0.41	0.78	1.00	4,641	298	114,209
Oakland Park STP	VA0086789	0.14	3.00	1,279	0.10	43	30.00	12,791	1.00	1.00	1.00	1,279	43	12,791
Haymount WWTF (5)	VA0089125	0.96	3.00	8,771	0.10	292	30.00	87,712	1.00	1.00	1.00	8,771	292	87,712
Hopyard Farms STP	VA0089338	0.50	3.00	4,568	0.10	152	30.00	45,683	1.00	1.00	1.00	4,568	152	45,683
Mountain Run STP	VA0090212	0.00	3.00	-	0.10	0	0.00	0	0.49	0.78	1.00	0	0	0
Rapidan STP	VA0090948	0.60	3.00	5,482	0.10	183	30.00	54,820	0.28	0.78	1.00	1,561	143	54,820
TOTALS:		50.89		451,544		15,052		4,515,467				351,480	13,895	4,515,467

[1] *lb/yr = MGD * mg/L * 2.2046 lb/kg * 3.785 L/gal * 365 days/yr*

[2] *Delivered WLA lb/yr = Discharged WLA (lb/yr) * Delivery Factor*

LOT WLA Worksheet
York River Basin

TN Concentration = 3.00 mg/L
TP Concentration = 0.10 mg/L

Discharger Name	VPDES Permit No.	Design Flow (MGD)	TN Conc. (mg/l)	**Discharged** TN Waste Load Allocation (lbs/yr) [1]	TP Conc. (mg/l)	**Discharged** TP Waste Load Allocation (lbs/yr) [1]	TSS Conc. (mg/l)	**Discharged** TSS Waste Load Allocation (lbs/yr) [1]	TN Delivery Factor	TP Delivery Factor	TSS Delivery Factor	**Delivered** TN Waste Load Allocation (lbs/yr) [2]	**Delivered** TN Waste Load Allocation (lbs/yr) [2]	**Delivered** TN Waste Load Allocation (lbs/yr) [2]
Western Refinery	VA0003018	53.80	3.00	491,553	0.10	16,385	30.00	4,915,534	1.00	1.00	1.00	491,553	16,385	4,915,534
HRSD - Mathews Courthouse STP	VA0028819	0.10	3.00	914	0.10	30	30.00	9,137	1.00	1.00	1.00	914	30	9,137
HRSD - York River STP	VA0081311	15.00	3.00	137,050	0.10	4,568	30.00	1,370,502	1.00	1.00	1.00	137,050	4,568	1,370,502
HRSD-West Point STP	VA0075434	0.60	3.00	5,482	0.10	183	30.00	54,820	1.00	1.00	1.00	5,482	183	54,820
Caroline County STP	VA0073504	0.50	3.00	4,568	0.10	152	30.00	45,683	0.59	0.71	0.64	2,710	107	29,105
Smurfit Stone - West Point	VA0003115	23.00	3.00	210,144	0.10	7,005	30.00	2,101,436	1.00	1.00	1.00	210,144	7,005	2,101,436
Parham Landing WWTP	VA0088331	2.00	3.00	18,273	0.10	609	30.00	182,734	1.00	1.00	1.00	18,273	609	182,734
RSA-Gordonsville STP	VA0021105	0.94	3.00	8,588	0.10	286	30.00	85,885	0.05	0.24	0.05	434	68	3,928
Ashland WWTP	VA0024899	2.00	3.00	18,273	0.10	609	30.00	182,734	0.61	0.56	0.70	11,156	340	127,083
Doswell WWTP	VA0029521	1.00	3.00	9,137	0.10	305	30.00	91,367	0.55	0.56	0.70	5,063	170	63,541
White Birch-Bear Island Paper Co.	VA0029521	4.20	3.00	38,374	0.10	1,279	30.00	383,741	0.48	0.56	0.70	18,482	714	266,873
Totopotomoy WWTP	VA0089915	10.00	3.00	91,367	0.10	3,046	30.00	913,668	0.80	0.73	1.00	72,958	2,209	913,668
TOTALS:		113.14		1,033,723		34,457		10,337,240				974,219	32,389	10,038,362

[1] *lb/yr = MGD * mg/L * 2.2046 lb/kg * 3.785 L/gal * 365 days/yr*

[2] *Delivered WLA lb/yr = Discharged WLA (lb/yr) * Delivery Factor*

LOT WLA Worksheet
James River Basin

TN Concentration = 3.00 mg/L
TP Concentration = 0.10 mg/L

Discharger Name	VPDES Permit No.	Design Flow (MGD)	TN Conc. (mg/l)	**Discharged** TN Waste Load Allocation (lbs/yr) [1]	TP Conc. (mg/l)	**Discharged** TP Waste Load Allocation (lbs/yr) [1]	TSS Conc. (mg/l)	**Discharged** TSS Waste Load Allocation (lbs/yr) [1]	TN Delivery Factor	TP Delivery Factor	TSS Delivery Factor	**Delivered TN Waste Load Allocation (lbs/yr) [2]**	**Delivered TN Waste Load Allocation (lbs/yr) [2]**	**Delivered TN Waste Load Allocation (lbs/yr) [2]**
Crewe WWTP	VA0020303	0.50	3.00	4,568	0.10	152	30.00	45,683	0.29	0.46	0.36	1,337	69	16,452
South Central WW Authority	VA0025437	23.00	3.00	210,144	0.10	7,005	30.00	2,101,436	1.00	1.00	1.00	210,144	7,005	2,101,436
Farmville WWTP	VA0083135	2.40	3.00	21,928	0.10	731	30.00	219,280	0.26	0.46	0.36	5,630	333	78,969
Tyson Foods – Glen Allen	VA0004031	1.07	3.00	9,776	0.10	326	30.00	97,762	0.16	0.46	0.15	1,531	151	14,265
Chickahominy WWTP	VA0088480	0.405	3.00	3,700	0.10	123	30.00	37,004	0.37	0.46	0.15	1,383	57	5,399
HRSD - VIP WWTP	VA0081281	40.00	3.00	365,467	0.10	12,182	30.00	3,654,672	1.00	1.00	1.00	365,467	12,182	3,654,672
HRSD - James River STP	VA0081272	20.00	3.00	182,734	0.10	6,091	30.00	1,827,336	1.00	1.00	1.00	182,734	6,091	1,827,336
HRSD - Williamsburg STP	VA0081302	22.50	3.00	205,575	0.10	6,853	30.00	2,055,753	1.00	1.00	1.00	205,575	6,853	2,055,753
JH Miles & Company	VA0003263	0.35	3.00	3,198	0.10	107	30.00	31,978	1.00	1.00	1.00	3,198	107	31,978
HRSD - Army Base STP	VA0081230	18.00	3.00	164,460	0.10	5,482	30.00	1,644,602	1.00	1.00	1.00	164,460	5,482	1,644,602
HRSD - Boat Harbor STP	VA0081256	25.00	3.00	228,417	0.10	7,614	30.00	2,284,170	1.00	1.00	1.00	228,417	7,614	2,284,170
HRSD - Nansemond STP	VA0081299	30.00	3.00	274,100	0.10	9,137	30.00	2,741,004	1.00	1.00	1.00	274,100	9,137	2,741,004
Honeywell - Hopewell	VA0005291	121.00	3.00	1,105,538	0.10	36,851	30.00	11,055,383	1.00	1.00	1.00	1,105,538	36,851	11,055,383
Philip Morris - Park 500	VA0026557	2.90	3.00	26,496	0.10	883	30.00	264,964	1.00	1.00	1.00	26,496	883	264,964
Hopewell RWTP	VA0066630	50.00	3.00	456,834	0.10	15,228	30.00	4,568,340	1.00	1.00	1.00	456,834	15,228	4,568,340
Sustainability Park	VA0002780	2.10	3.00	19,187	0.10	640	30.00	191,870	1.00	1.00	1.00	19,187	640	191,870
Georgia Pacific	VA0003026	10.87	3.00	99,316	0.10	3,311	30.00	993,157	0.60	0.66	0.80	59,256	2,179	792,133
MeadWestvaco	VA0003646	35.00	3.00	319,784	0.10	10,659	30.00	3,197,838	0.11	0.66	0.80	34,374	7,014	2,550,567
BWX Technologies Inc.	VA0003697	0.50	3.00	4,568	0.10	152	30.00	45,683	0.65	0.66	0.80	2,956	100	36,437
Dominion-Chesterfield	VA0004146	13.50	3.00	123,345	0.10	4,112	30.00	1,233,452	1.00	1.00	1.00	123,345	4,112	1,233,452
E I du Pont - Spruance	VA0004669	23.33	3.00	213,159	0.10	7,105	30.00	2,131,587	1.00	1.00	1.00	213,159	7,105	2,131,587
Lees Carpets	VA0004677	2.00	3.00	18,273	0.10	609	30.00	182,734	0.58	0.66	0.80	10,614	401	145,747
Greif Inc.	VA0006408	6.50	3.00	59,388	0.10	1,980	30.00	593,884	0.65	0.66	0.80	38,424	1,303	473,677
Powhatan CC STP	VA0020699	0.47	3.00	4,294	0.10	143	30.00	42,942	0.89	0.66	0.80	3,803	94	34,250
Buena Vista STP	VA0020991	2.25	3.00	20,558	0.10	685	30.00	205,575	0.55	0.66	0.80	11,252	451	163,965
Clifton Forge STP	VA0022772	2.00	3.00	18,273	0.10	609	30.00	182,734	0.26	0.66	0.80	4,776	401	145,747
Lake Monticello STP	VA0024945	0.995	3.00	9,091	0.10	303	30.00	90,910	0.66	0.66	0.80	5,993	199	72,509
Lynchburg STP	VA0024970	22.00	3.00	201,007	0.10	6,700	30.00	2,010,070	0.65	0.66	0.80	130,052	4,409	1,603,214
Falling Creek WWTP	VA0024996	10.10	3.00	92,280	0.10	3,076	30.00	922,805	1.00	1.00	1.00	92,280	3,076	922,805
RWSA-Moores Creek Regional STP	VA0025518	15.00	3.00	137,050	0.10	4,568	30.00	1,370,502	0.66	0.66	0.80	90,351	3,006	1,093,100
Covington STP	VA0025542	3.00	3.00	27,410	0.10	914	30.00	274,100	0.21	0.66	0.80	5,680	601	218,620
All. Co.-Low Moor STP	VA0027979	0.50	3.00	4,568	0.10	152	30.00	45,683	0.26	0.66	0.80	1,194	100	36,437
Amherst STP	VA0031321	0.60	3.00	5,482	0.10	183	30.00	54,820	0.33	0.66	0.80	1,818	120	43,724
Proctors Creek WWTP	VA0060194	27.00	3.00	246,690	0.10	8,223	30.00	2,466,904	1.00	1.00	1.00	246,690	8,223	2,466,904
Richmond WWTP	VA0063177	45.00	3.00	411,151	0.10	13,705	30.00	4,111,506	1.00	1.00	1.00	411,151	13,705	4,111,506
Henrico County WWTP	VA0063690	75.00	3.00	685,251	0.10	22,842	30.00	6,852,510	1.00	1.00	1.00	685,251	22,842	6,852,510
MSA Lexington-Rockbridge WQCF	VA0088161	3.00	3.00	27,410	0.10	914	30.00	274,100	0.31	0.66	0.80	8,389	601	218,620
All. Co.-Lower Jackson River STP	VA0090671	1.50	3.00	13,705	0.10	457	30.00	137,050	0.26	0.66	0.80	3,582	301	109,310
HRSD - Ches.-Elizabeth STP	VA0081264	24.00	3.00	219,280	0.10	7,309	30.00	2,192,803	1.00	1.00	1.00	219,280	7,309	2,192,803
	TOTALS:	683.34		6,243,455		208,116		62,434,589				5,655,701	196,335	60,186,218

[1] *lb/yr = MGD * mg/L * 2.2046 lb/kg * 3.785 L/gal * 365 days/yr*

[2] *Delivered WLA lb/yr = Discharged WLA (lb/yr) * Delivery Factor*

LOT WLA Worksheet
Eastern Shore

TN Concentration = 3.00 mg/L
TP Concentration = 0.10 mg/L

Discharger Name	VPDES Permit No.	Design Flow (MGD)	TN Conc. (mg/l)	**Discharged** TN Waste Load Allocation (lbs/yr) [1]	TP Conc. (mg/l)	**Discharged** TP Waste Load Allocation (lbs/yr) [1]	TSS Conc. (mg/l)	**Discharged** TSS Waste Load Allocation (lbs/yr) [1]	TN Delivery Factor	TP Delivery Factor	TSS Delivery Factor	**Delivered TN Waste Load Allocation (lbs/yr) [2]**	**Delivered TN Waste Load Allocation (lbs/yr) [2]**	**Delivered TN Waste Load Allocation (lbs/yr) [2]**
Onancock WWTP (2)	VA0021253	0.75	3.00	6,853	0.10	228	30.00	68,525	1.00	1.00	1.00	6,853	228	68,525
Cape Charles Town WWTP (1)	VA0021288	0.50	3.00	4,568	0.10	152	30.00	45,683	1.00	1.00	1.00	4,568	152	45,683
Shore Memorial Hospital	VA0027537	0.10	3.00	914	0.10	30	30.00	9,137	1.00	1.00	1.00	914	30	9,137
Tyson Foods - Temperanceville	VA0004049	1.25	3.00	11,421	0.10	381	30.00	114,209	1.00	1.00	1.00	11,421	381	114,209
Tangier WWTP	VA0067423	0.10	3.00	914	0.10	30	30.00	9,137	1.00	1.00	1.00	914	30	9,137
TOTALS:		2.70		24,670		821		246,690				24,670	821	246,690

[1] *lb/yr = MGD * mg/L * 2.2046 lb/kg * 3.785 L/gal * 365 days/yr*
[2] *Delivered WLA lb/yr = Discharged WLA (lb/yr) * Delivery Factor*

Exhibit 3

“Potomac River now healthier than in ‘50s, study shows”

The Washington Post

Potomac River now healthier than in '50s, study shows

Washington Post Staff Writer
By David A. Fahrenthold
Tuesday, September 7, 2010; 11:28 PM

The Potomac River is cleaner now than it has been in decades, thanks largely to upgrades at Washington's sewage plant - and the proof is on the river bottom, where thickets of underwater grass are replacing mud and murk, according to a new scientific study.

The study, released Tuesday, paints an evocative picture of the Potomac's rebound from the 1960s, when its bottom was bare mud, its algae-choked water was AstroTurf green, and President Lyndon B. Johnson called the river a national disgrace.

Today, the river is clearer and heavily carpeted with grass. Scientists found that the Potomac's critical grass beds had doubled in size since 1990.

"These conditions are actually better than they were in the 1950s. The portion of the Potomac that we're talking about was completely devoid of vegetation in the 1950s," said Nancy Rybicki, a scientist with the U.S. Geological Survey and a co-author of the study.

But despite that good news, the Potomac is still full of other pollutants that have led District authorities to warn about swimming in it and eating its fish. Its ecosystems have been scrambled by invasive species, including snakehead fish. And an unknown chemical in the water is making male bass grow eggs.

So, if the Potomac is an environmental success story, that shows how low the bar for success has been set - both for the long-troubled river and for the nation's other polluted rivers and bays.

"When this all started . . . the problems with the water were visible and palpable, for the m ost part. We had this green goop" on the water, said Ed Merrifield, an environmental a ctivist whose title is Potomac riverkeeper. "What we're left [with] are the invisible problems, which can still be very harmful to us."

The study covered the period from 1990 to 2007 and 50 miles of river, from Chain Bridge downstream to Maryland Point in Charles County. It was an unusually wide-angle look at the Potomac's rebound, which has

The Washington Post

Potomac River now healthier than in '50s, study shows

mirrored gains in Boston Harbor and Cleveland's once-flammable Cuyahoga River.

The Potomac, which begins in Appalachian valleys to the west, once teemed with oysters, sturgeon and shad, but it was poisoned by sewage from the growing capital. By 1969, authorities had pronounced the river "a severe threat to the health of anyone coming into contact with it."

Its comeback has been closely tied to the Blue Plains treatment plant, which handles waste from the District and parts of Montgomery, Prince George's, Fairfax, Loudoun and Arlington counties. Its outflow is a river in itself: about 300 million gallons a day of treated sewage, enough to fill RFK Stadium.

In the past decade, responding to mandates from federal regulators, the plant has added $1 billion in new efforts that allow bacteria to consume the algae-feeding pollutant nitrogen in sewage. The new study determined that between 1990 and 2007, the average level of nitrogen in the river fell by nearly half.

The result, scientists said, was less murk. With less algae in the water, more light gets through to the river bottom. Given the chance, the river's plants came back, the study found: first some nonnative species, then an expanding number of grasses that had always lived in the Potomac. They now cover 8,441 acres of river bottom - and help their own cause by filtering dirt and pollutants out of the current as it passes.

The Washington Post

Potomac River now healthier than in '50s, study shows

It's not just scientists who have noticed the difference. Steve Chaconas, a bass guide who has worked the Potomac for more than 20 years, said fish can hide and hunt in the cool waters under the leaves. So that's where he fishes, dangling lures at the edge of grass beds in tributaries like Broad Creek and Piscataway Creek.

"If you find grass, you'll find bass," Chaconas said Tuesday. Chaconas said that recent construction on the Woodrow Wilson Bridge seemed to destroy some nearby grass beds but that overall the river is "absolutely a much better place to fish."

But even as the Potomac demonstrates the success of clean-water laws, it also reveals their limits.

The river is tainted by other pollutants that don't flow out of a sewage-plant pipe. Mercury, belched out of power-plant smokestacks, settles on the water and taints fish. The chemicals that cause the river's "intersex" fish could be pesticides or industrial chemicals, or both.

"We're doing other marvelous things with chemistry . . . that also can get into the environment and in very low concentrations can have these effects," said Donald F. Boesch, president of the University of Maryland Center for Environmental Science. Blue Plains is planning about $900 million in further improvements, but it seems unlikely to solve what's altering the fish. "They're caused by different aspects of how we live," Boesch said.

Also, the improvement in the Potomac means that cleaner water will flow into the Chesapeake Bay. But it does not reveal a cure for fixing the bay's long-standing problems.

According to Environmental Protection Agency estimates, just 19 percent of the Chesapeake's nitrogen comes from wastewater-treatment plants like Blue Plains. But 39 percent comes from manure and fertilizer washing off farms, and 12 percent comes from animal waste and fertilizer that flow into urban storm sewers. Fixing those systems will require much more money and perhaps unpopular crackdowns.

In recent days, state governments around the Chesapeake watershed have submitted

The Washington Post

Potomac River now healthier than in '50s, study shows

detailed plans describing how they would solve these problems. The EPA says it will take two weeks to declare if they are sufficient.

"Where we've had control and we've had funding, we're starting to see the results of doing the right thing. The difficult thing ahead is the non-point sources" where pollution doesn't flow through a pipe, said Beth McGee, of the nonprofit Chesapeake Bay Foundation.

"We've solved maybe 20 percent of it," she said.

Exhibit 4

"Algae blooms strike Hampton Roads waters – again"

Hampton Roads, VA - 11/03/2010
55° Overcast Light Rain
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Algae blooms strike Hampton Roads waters - again.

Posted to: Environment News Suffolk Login or register to post comments

Red tide can be seen, in the upper half of this photograph, in the waters of the James River near the Monitor-Merrimac Memorial Bridge Tunnel Tuesday afternoon, Aug. 10, 2010. (Bill Tiernan | The Virginian-Pilot)

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RELATED
- Algae blooms spreading in Chesapeake Bay - Aug. 20, 2009
- Fueled by heat and pollution, algae splotches waterways - Aug. 23, 2008
- Tests show red tide in local waters toxic to fish - Sep. 7, 2007

By Hattie Brown Garrow
The Virginian-Pilot
© August 12, 2010

Swirls of mahogany-colored algae have been spotted in waterways in Hampton Roads over the past few weeks, a Chesapeake Bay Foundation official said Wednesday.

A combination of warm water and nutrient pollution spawn the algal blooms, which have become an annual occurrence, said Chris Moore, a science advocate for the foundation. Large amounts of nitrogen and phosphorus coming from lawn fertilizers, industrial discharges and other sources flow into the Bay and cause the algae to increase exponentially.

"It's kind of this unfortunate reminder that we need to do a lot more to improve the health of our waterways," Moore said.

Many people call such blooms a red tide, but Moore says that's not the case in this instance.

"When most people mention red tides, they are usually talking about algae that has a toxic effect," he said.

Though these blooms are not necessarily toxic, they are an unwelcome sight. When the algae die, they sink to the bottom and can consume too much oxygen, killing other aquatic life. Scientists have also found that excessive algae growth can irritate fish and shellfish, Moore said.

Foundation officials first saw the blooms about two weeks ago in the Eastern Branch of the Elizabeth River, Moore said. He noticed a large amount of algae from Ocean View to Chic's Beach during a boat ride Tuesday.

Blooms were also seen overhead Wednesday near Fort Monroe, the Hampton Roads and Monitor-Merrimac Memorial bridge-tunnels, at the mouth of the Nansemond River and in the James River by the Newport News waterfront.

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ANNUAL INSTALLMENT

Submitted by SamD **on Thu, 08/12/2010 at 11:00 am.**

AR0030585

Algae Blooms in the Hampton Roads Area (Photographed 8/10/10)

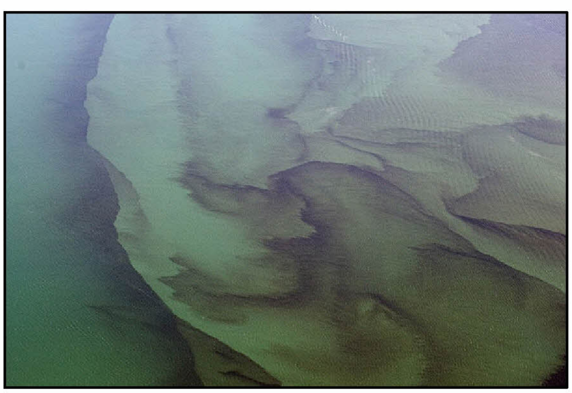

Exhibit 5

Effects of Fertilizer Management Practices on Urban Runoff Water Quality

Effects of Fertilizer Management Practices on Urban Runoff Water Quality

W. Lee Daniels[1], Mike Goatley[1], Rory Maguire[1] and David Sample[2]

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June 1, 2010

Executive Summary

Stormwater nutrient runoff loadings within the Chesapeake Bay watershed are being increasingly regulated, particularly through implementation of watershed level TMDL programs and associated runoff and development restrictions. One potential alternative for significantly reducing nutrient runoff loadings is to vigorously reduce or eliminate applications of nitrogen (N) and phosphorus (P) fertilizers and/or to implement a wide range of intensive fertilizer/ soil/plant management practices. To focus and frame this study, we considered the potential impacts of the following intensive N and P fertilization management practices on potential N and P losses to stormwater:

A. *Prohibition of all N and P applications except for new seedings;*
B. *Ban on P except for new seedings or critical areas; slow-release N formulations only;*
C. *Soil-test only for P application rates; strict annual and one-time N limitations;*
D. *Ban on sidewalk/driveway applications of fertilizers and clippings;*
E. *Use of organics such as composts;*
F. *Fertilizers applied only by certified applicators*

It is clear that implementation of a wide range of fertilizer management practices and/or policies could significantly reduce total stormwater runoff of both N and P. The scientific literature indicates that by carefully restricting application rates (e.g. no more than 1 1b/1000 ft^2 of soluble N at least 30 days apart for cool season grasses), that N runoff losses from well-managed turfgrass will be minimal. Similarly, use of slow-release N fertilizers or labeled organic-N sources would also significantly reduce the risk of N runoff losses. Restricting P-fertilizer applications to urban soils to correspond to actual plant needs (via soil testing) is the most effective way to reduce P-runoff losses over time. However, limiting long-term P release from soils that have received repeated and excessive fertilizer applications will be challenging. The single most important factor or practice for reducing short-term nutrient runoff would be to limit or prevent application and losses of fertilizers and clippings from impervious surfaces. We do not support an across-the-board ban on all N and P fertilizer applications for the simple reason that we cannot establish and maintain healthy vegetation to control soil erosion and filter sediment out of overland flow/runoff without adequate plant-available N and P.

Overall, we believe that a combination of **Options B, D and F** would be the most effective for both short- and long-term reductions in N and P loadings to stormwater runoff from individual home lawns and landscaped areas. Alternatively, where fertilizers are applied by commercial entities or certified individuals, the prescriptions laid out in **Option C** should be rigorously followed. Implemented together, these practices would (1) limit P applications in all settings to those prescribed by a current and valid soil test and (2) strictly limit total annual and one-time N application rates. Concurrently, (3) local policies should be established to ensure that fertilizers and clippings are not allowed to be applied and/or retained on impervious surfaces. Finally, where required and necessary, (4) fertilizers should be prescribed and managed by certified applicators. There are very few studies currently available that directly measure the effects of reduced or limited N and P fertilization practices on runoff nutrient loadings. Several studies indicate a potential 25 to 50% reduction in total-P loading to stormwater within several years. The literature also indicates that significant reductions (10 to 20%) in total N loadings to stormwater could be achieved through intensive fertilizer management practices. Local monitoring/validation of these reductions is recommended.

Introduction

Stormwater nutrient runoff loadings within the Chesapeake Bay watershed are being increasingly regulated by Chesapeake Bay Program initiatives, particularly through implementation of watershed level TMDL programs and associated runoff and development restrictions. In regions such as the urban/suburban areas of the Chesapeake Bay watershed, many have voiced concerns that compliance with TMDL based nutrient runoff standards may seriously hamper new development or may in fact be unattainable with current landuse/soil/plant management practices. One potential alternative for significantly reducing nutrient runoff loadings is to vigorously reduce or eliminate applications of nitrogen (N) and phosphorus (P) fertilizers and/or to implement a wide range of intensive fertilizer/soil/plant management practices. For example, one current study from Michigan (Lehman et al., 2009) reports a 28% reduction in total-P loadings to stormwater one year after implementation of a local regulation that banned or greatly restricted fertilizer P applications. Another EPA supported study (Lake Access, 2010) reports over 50% reduction in total P runoff in 2001/2002 between two adjacent watersheds due to P fertilizer restrictions. In contrast, Minnesota enacted statewide limitations on fertilizer P applications in 2002 and 2004 which greatly reduced total-P applications (as controlled by site-specific soil testing), but significant decreases in P in receiving streams had not been validated or quantified by 2007 due to high variability in their water quality data sets (Minn. Dept. Ag., 2007). Meanwhile, a directly related study in Wisconsin (Garn, 2002) found that stormwater runoff P events from home lawns were more frequent than expected and significantly enriched in P which was directly related to soil-test P levels. That same study reported very little total-N runoff from the same densely developed lakeshore lawns. Other nutrient runoff studies (as discussed later) report very different behavior for N vs. P in both agricultural and urbanized areas.

Thus, while the studies cited above (and other related reports) clearly indicate a potential for reduced stormwater nutrient loadings through enhanced fertilizer management or restrictions, a number of inter-related factors including soil-site properties, plant nutrient uptake patterns and efficiencies, and local surface hydrologic conditions must also be factored into our discussion. Furthermore, active construction and other site/soil disturbances can generate pulses of sediment-bound nutrient loadings that are quite different from stormwater runoff contributions from established lawns and landscapes. Similarly, direct runoff of mis-applied fertilizers, animal droppings and lawn clippings and leaves from sidewalks and other impervious surfaces must also be considered and managed appropriately to reduce net stormwater N and P levels.

The overall goal of this paper is to discuss and describe the probable effects of a wide range of fertilizer nitrogen (N) and phosphorus (P) application and management practices on potential nutrient runoff loadings in developed and urbanizing environment. Specifically, we will discuss how direct N and P application restrictions and intensive soil/plant management alternatives might reduce nutrient runoff loadings versus current conventional practices. To accomplish this we will review current scientific knowledge on the behavior of nitrogen (N) and phosphorus (P) in soil/plant systems with a particular focus on intensively managed urban home lawns and landscapes. The known relationships between soil/plant N and P dynamics and their potential contributions to runoff loadings will be discussed in detail.

It is important to point out that due to the dearth of published scientific studies on this particular topic, our conclusions are necessarily based on the best literature and knowledge from the fields of agricultural and urban soil nutrient management coupled with those directly applicable to urban runoff as influenced by fertilization practices.

Fertilizer application reduction strategies

To properly frame this paper and our evaluation, we assume that any of the following potential limitations or management restrictions could be likely candidates for use alone or in various combinations in urban/suburban areas of the Chesapeake Bay Watershed:

A. *Prohibition of all N and P applications except for new seedings*. This would be the most drastic proposed restriction. Fertilizers would only be allowed on "new ground" seedings, active construction sites, etc., with very restricted rates (based on soil test for P) and only with associated sediment/runoff control BMPs in place.

B. *Ban on P except for new seedings and critical areas; slow-release N formulations only*. This option *assumes* that most well-established home lawns and landscapes will not be soil P limited, but exceptions would be needed for "new ground" seedings, active construction sites, or critical renovation areas in home lawns where soil test validates an actual P deficiency. At least 25% of total-N applied must be from a slow-release source with strict one-time and annual application rate limitations as described on page 18.

C. *Soil-test only for P application rates; strict annual and one-time N limitations*. Fertilizer P applications would only be allowed when indicated as necessary by soil test (M^- or lower). Total N would be limited to no more than 3.5 lbs of water soluble N/1000 ft^2 per year with no more than 1 lb/1000 ft^2 per application at least 30 days apart for cool season grasses. For warm-season grasses, the annual N level can be as high as 4.0 lbs N/1000 ft^2. This would in fact reflect current "best turf management practice" in the region and would be similar to Virginia DCR Nutrient Management Plan restrictions for managed turfgrass areas. For this option (and B above) to be viable, fertilizer sales would need to restricted in some fashion and/or certified applicators would need to apply all materials.

D. *Ban on sidewalk/driveway applications.* Should be a mandatory BMP and applies to both fertilizers and lawn clippings/leaves/trimmings.

E. *Use of organics*. Organic fertilizer sources (e.g. composts and manures) can offer significant secondary soil building benefits (e.g. aggregation, water holding and micronutrients) along with slow release N and P behavior. However, these products are highly variable and over-application can lead to runoff nutrient losses as well.

F. *Fertilizers applied only by certified applicators*. Both Virginia and Maryland have relatively new regulations that require all private sector (e.g. lawn care firms) non-agricultural fertilizer applications to be directed by a state-certified individual. More rigorous application of this policy to all urban lawns and landscapes should be considered. This approach would necessarily need to be coupled with site-specific soil testing and appropriate N and P application restrictions.

Other alternatives or combinations of restrictions and management practices are likely to evolve over time. Our goal in this paper is to provide the reader with the appropriate understanding and background to predict their potential impacts on runoff N and P losses.

<u>Current EPA model assumption on N and P loadings vs. urban land use cover types.</u>

While it was beyond the scope and intent of this document to review and critique the current assumptions that USEPA and its cooperators are using to simulate runoff nutrient loadings of N and P in its current version of the "Bay Model", we do provide the following summary as a frame of reference for our findings. According the EPA's on-line guidance documentation (USEPA, 2008a):

> *A standard practice for estimating nutrient loads from developed land is the simple method, in which the annual nutrient load is determined by the annual runoff multiplied by the median event mean concentration (EMC) (Schueler, 1987; Pitt et al., 2004). The annual runoff is typically estimated from rainfall, detention storage, and the runoff coefficient, or in the case of the Phase 5 simulation, is directly simulated and the runoff estimates are taken directly from model output. We estimate the annual discharge of total surface and groundwater, from the Phase 5 model to represent the runoff, which is consistent with the Phase 1 observed data we use. Simply multiplying the annual discharge by the concentration gives an estimate of loading.*

Accordingly, the two critically important factors used to derive the annual runoff loadings as presented in Table 1 are (a) the median assumed nutrient concentrations in stormwater and (b) the % impervious surface. Furthermore, the EPA asserts that the literature and data sets available for their review varied little in relative runoff concentrations and therefore they established median concentrations of 2.0 mg/l total N and 0.27 mg/l total P for *all initial inputs* and then the model varies the proportional loadings given in Table1 based on the relative water balance assumptions in the runoff model employed (e.g. Schueler's "simple method"). The EPA's assessment of literature related to N and P losses from active construction also revealed a wide range of reported losses and their estimated loadings from that land use type as shown in Table 1. The loading values shown there assume no sediment control BMPs are in place.

The importance of direct runoff from impervious surfaces has long been recognized in the turfgrass nutrient management area and by landuse planners. For example over 10 years ago, Arnold and Gibbons (1996) defined four basic qualities of "imperviousness" that make it an important indicator of environmental quality: (1) while an impervious surface does not directly generate pollution, there is a clear link between an impervious surface and the degradation of water quality; (2) urbanization logically increases the area of impervious surfaces; (3) an impervious surface prevents natural pollutant processing in the soil by preventing percolation; and (4) impervious surfaces convey pollutants into the waterways, typically through the direct piping of stormwater.

Table 1. Runoff loadings for land uses as presented in USEPA (2008a) Chesapeake Bay Model support documents. A range of land use loading values are presented here for reference. Loadings from "urban lands" are based upon combined contributions of the "pervious developed" and "impervious developed" values shown below. Bare Construction values assume no sediment control BMPs.

Land Use	**Median Total-N Load (lb/ac-yr)**	**Median Total-P Load (lb/ac-yr)**
conventional crop receiving manure	23	2.0
conventional crop without manures	23	2.5
conservation crop receiving manures	XX	1.4
alfalfa	5.5	0.7
hay fertilized	6.0	0.8
hay unfertilized	4.0	0.4
pasture	4.5	0.7
pervious developed	8.7	1.1
impervious developed	11.8	2.1
nurseries	240	85
bare-construction	25	7.0
extractive	21.5	3.5

For reasons discussed later in this paper, we question the use of one median runoff concentration value for N and P in the Bay Model simulations. However, we also acknowledge the fact that the literature is scant with specific catchment-specific measured values which could be used to better specify this critical modeling parameter. Similarly, the active construction runoff loadings appear high, particularly for P where subsoils are the major sediment contributor. However, we can only assume that the EPA chooses to be conservative here.

Review of Related Regional Reports and Data Sets on Urban Runoff

Large, continuous flow and water quality records of urban catchments are not common. The Occoquan watershed has been monitoring gages upstream from Occoquan dam (a public water supply intake) from 1982-present (Dougherty et al., 2006). Upstream of the monitoring gages, the contributing catchments' sizes are on the order of 200 mi^2 with heterogeneous land use. Thus, this data is not at the scale needed for this analysis.

The Long Term Ecological Research (LTER) site in Baltimore consists of an 80 acre forested catchment and 6 urban catchments ranging in size from 19 to 40,200 acres in size, with impervious proportions from 1 to 41% (Groffman et al., 2004). Continuous storm flows are not collected. The focus of the research in this area is N retention, and the authors report that N retention was high in suburban catchments, with sources attributed to atmospheric deposition and lawn fertilizer. In a later study with surveys and soil testing aimed at estimating the fertilizer N application rate, Law et al. (2004) found a wide range in application rate, with a mean of 87.1 lb N/ac/yr (97.6 kg N/ha/yr) and a variance of 78.8 lb N/ac/yr (88.3 kg N/ha/yr). The authors attributed the main differences in application rate to a variety of physical factors such as soil bulk density and N, and social factors including property valuation and structural age.

The LTER Plum Island research site has collected 2 years of data from a range of catchments 148 to 1037 acres in size across a range of urban development, with impervious surfaces ranging from 1.3-28.6%. These catchments are heterogeneous in land use, but contain between 6.6-89% of residential land use (Wollheim et al., 2005). The authors found that impervious surfaces from urban development result in increased water runoff, increased N loading and N exports, and decreased N retention through a variety of mechanisms, not all of which are measureable or understood. Some of the best measurements of urban runoff quality for small catchments were taken as part of the National Urban Runoff Program (NURP). Metropolitan Washington Council of Government (MWCOG) conducted a study of detention ponds for various land uses (MWCOG 1983). The influent watersheds for Burke Pond (51UR03, Virginia) and Westleigh (51UR15, Maryland) were 18.3 and 28.4 acres, with impervious ratios of 32.7% and 21.2%, respectively. Continuous storm measurements were collected for a period slightly more than a year. These catchments were considered stable during the time period of the study. Figure 1 illustrates runoff depth for Burke and Westleigh. Burke, while smaller, maintains a much greater median runoff depth than Westleigh due to its higher impervious surface. Normalized Event Mean Concentration (EMCs) for Sediment and COD are provided in Figure 2. These values can be converted to load in kg/ha/year by multiplying by the annual runoff volume through the simple method. Sediment values are essentially the same for each. Phosphorus values and P-forms are illustrated in Figure 3; the same for N forms as shown in Figure 4. The values for total P are roughly equivalent for the two watersheds, the higher variance shown in the Westleigh catchment may in part be due to the larger extents of pervious lawns. Little difference is shown in Nitrogen exports from the same watersheds (Figure 4).

Evaluating the effects of development upon urban runoff quality necessitates observing small, homogenous catchments over a long period of record. For residential development, a longer record period can enable evaluation of the different phases of development. Line and White (2007) monitored a 10 acre developing catchment paired with an 8.2 acre undeveloped catchment in the central Piedmont region of North Carolina for a period of 5.5 years. Phases of development included clearing, followed by two phases of building. The first phase consisted mainly of house construction and landscape development. The second and final phase consisted mainly of construction of roads and storm sewers. Table 2 summarizes the relative loading rates for each phase of development.

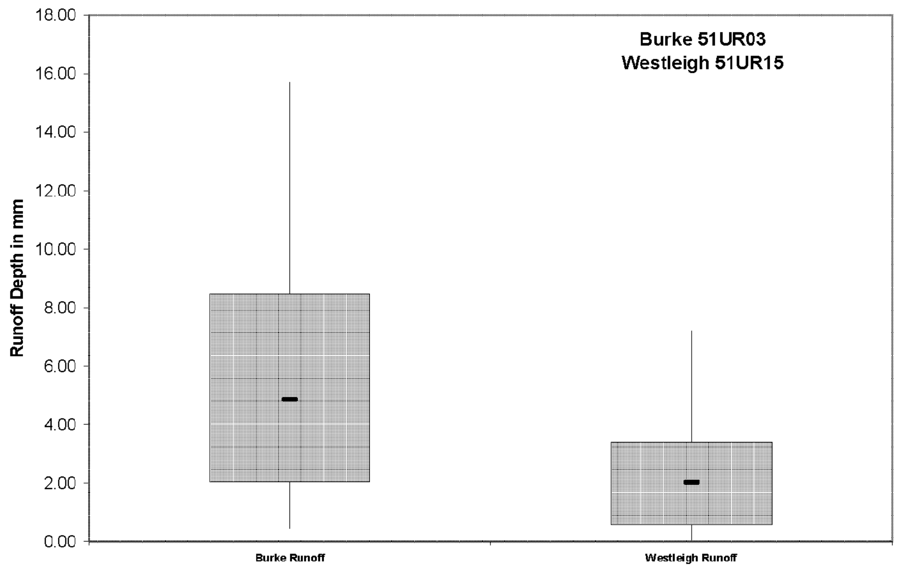

Figure 1. Distribution of Runoff volumes for Burke and Westleigh urban Catchments, Metropolitan Washington. *Note: 25.4 mm = 1.0 inch.*

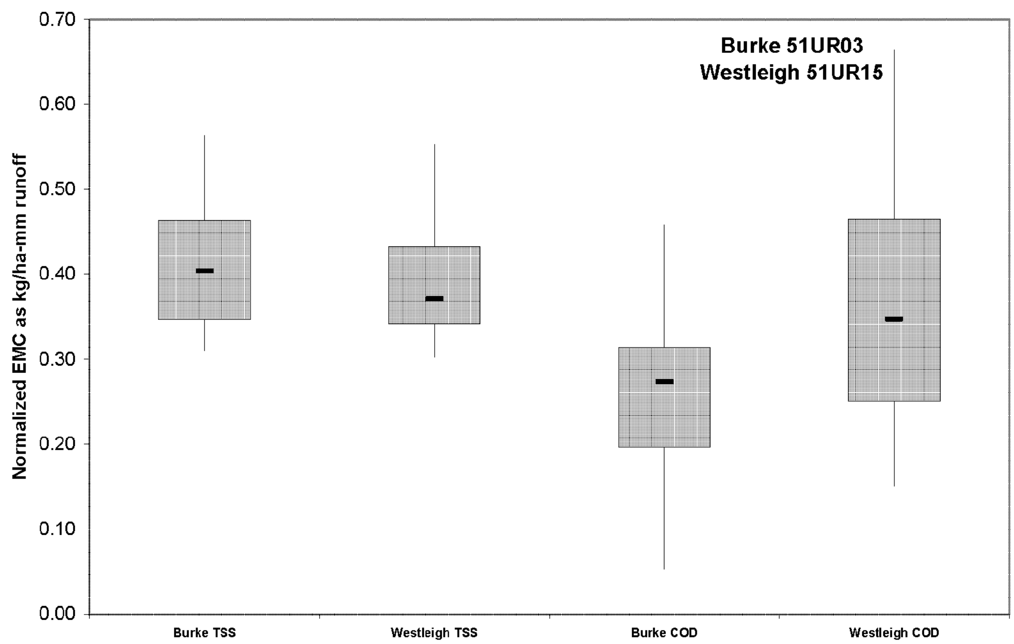

Figure 2. Distribution of TSS and COD loading for Burke and Westleigh urban catchments, Metropolitan Washington. *Note: 1.0 lb/acre = 1.12 kg/ha.*

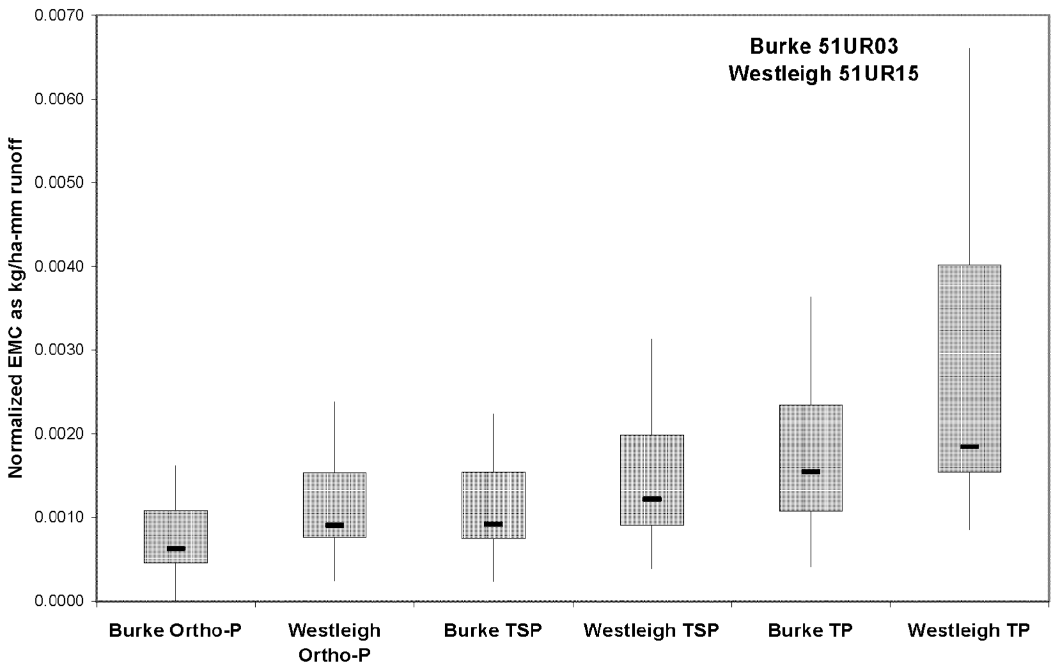

Figure 3. Distribution of P Loadings (and speciation) for Burke and Westleigh urban catchments, Metropolitan Washington. *Note: 1.0 lb/acre = 1.12 kg/ha.*

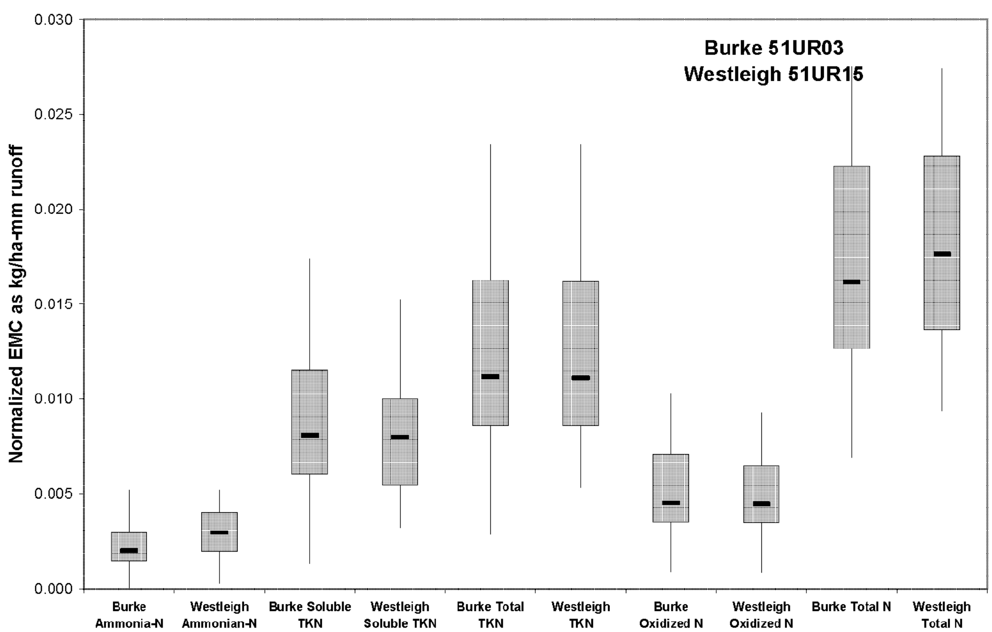

Figure 4. Distribution of N Loadings (and speciation) for Burke and Westleigh urban catchments, Metropolitan Washington. *Note: 1.0 lb/acre = 1.12 kg/ha.*

Table 2: Pollutant export rates during urban development from a small catchment

Type	Phase	Period Length (years)	Avg Ratio of Runoff to Rainfall	TSS	TP	Nitrate+ Nitrite-N	TKN	NH_4-N	TN
				Loading in kg/ha-yr					
Developing Catchment	Clearing	0.7	0.5	29250	2.8	2	8.4	0.7	10.4
	Building-1st phase	1.4	0.6	6170	1.3	5.9	25.6	3.3	31.5
	Building-2nd phase	3.5	0.55	1958	1.7	1.8	16.2	1.7	18
Undeveloped Catchment	N/A	5.6	0.21	349	0.5	1	5.3	0.2	6.3

Source: Line and White (2007). *Note: 1.0 lb/acre = 1.12 kg/ha.*

Construction sites are a special case, and difficult to predict because of their spatially disperse and sporadic nature. Monitored sites would also be highly variable, and likely unrepresentative. EPA is presently revising the General NPDES Stormwater Permit for Construction Activities. The USEPA conducted an analysis in support of its effluent guidelines (USEPA 2008b). From this source, the estimated sediment loss from typical construction sites in Washington, DC was estimated; these data are found in Table 3. Based upon average construction activities and modeled conditions, the estimated sediment load from Virginia from construction sites, based upon multiple control scenarios is found in Table 4. These are "edge of field" numbers, to become "edge of stream"; EPA typically reduces them by 85% to reflect attenuation and settling. For comparison, the total Virginia sediment load from all sources was 2,204,161 tons/year. The USEPA Chesapeake Bay program currently uses 40 tons/acre/year for uncontrolled construction site sediment loading. EPA proposes to apply option 3 in the proposed permit, which would be an 87% reduction from no control.

Nutrient and sediment loading from the Occoquan watershed were computed for the period from 2003-2008 for comparison (Grizzard, 2010) in one particularly relevant, but unpublished study. The Occoquan watershed has two main tributaries, Occoquan Creek (less urbanized, 369 mi^2), and Bull Run Creek (more urbanized, 201 mi^2). Occoquan Creek had a Total N, Total P, and TSS loading of 5.5 lb/ac/yr (6.2 kg/ha/yr), 6.2 lb/ac/yr (0.7 kg/ha/yr), and 370 lb/ac/yr (415 kg/ha/yr), respectively. Bull Run Creek had a Total N, Total P, and TSS load of 4.0, 0.7 and 558 lb/ac/yr (4.5, 0.8, and 625 kg/ha/year), respectively.

Due to the existence of complete vegetative cover, associated mitigation of raindrop impact and internal sediment detention, loss of sediment-bound N and P will be negligible from established and well-managed home lawns and landscapes (Soldat and Petrovic, 2008). The exception would be where clippings or other low density particulate organic matter was mobilized in overland flow. However, where site development and construction removes established vegetation and litter layers, the highest risk is clearly associated with previously P-enriched topsoil layers. This risk will be highest where the soil was previously managed for agricultural production or intensive turf. P runoff risk would be lowest where forest covers are removed. Regardless, all topsoil (A+E horizon) materials should be carefully segregated and protected on-site, seeded to a temporary vegetative cover, and surrounded by silt fences, compost berms or other appropriate sediment control BMPs. While exposed subsoil materials (typically Fe- and clay-rich Bt and C horizons) may pose a significant site-specific risk for sediment loss, their effect on nutrient levels in runoff would be negligible. In fact, these subsoil materials (particularly yellow/red, acidic clays) would actually be expected to adsorb soluble P forms from overland or channelized flow paths and may thereby actually limit P-losses to some extent. That being said, once sediment bound P forms are deposited into anaerobic zones in stormwater basins or wetlands, this Fe-bound P will be reduced and become bioavailable.

Table 3: Estimated Sediment Loss from Typical Construction Sites in Washington, DC

Estimated Sediment Loss, Wash DC, Tons/Acre, CASE:	Low	Average	High
Large, Medium, and Small Transportation Model Construction Projects	96.5	133.58	173.39
Large and Medium Residential Model Construction Projects	138.15	194.91	256.99
Large and Medium Nonresidential Model Construction Projects	156.46	222.21	294.57
Small Residential and Small Nonresidential Model Construction Projects	111.34	155.3	202.85

Source: US EPA 2008b

Table 4: Estimated Total Construction Site Sediment Loads for Virginia

Estimated Annual Construction Site Discharged Loads, Total for Virginia	**Low (Tons/year)**	**Avg (Tons/year)**	**High (Tons/year)**
No control	1,686,403	2,378,049	3,134,251
Option 1 (baseline, existing)[1]	722,808	1,019,253	1,343,368
Option 2[2]	306,259	430,958	567,018
Option 3[3]	87,599	122,142	159,486

[1]Option 1 would establish minimum sizing criteria for sediment basins used at construction sites with 10 or more disturbed acres draining to one location.
[2]Option 2 includes all Option 1 requirements, and numeric turbidity standards would be required to be met by all construction sites of 30 acres or greater.
[3]Option 3 contains the same requirements as Option 1, but also requires all sites with 10 or more acres of disturbed land to meet a numeric turbidity standard.

Source: US EPA 2008b

Soil N and P accumulation, mobility & management response

Forms of soil N and P and fertilizer recommendations

Native soils tend to be N and P deficient relative to plant requirements, with additions through fertilization necessary for optimum plant growth. This is particularly true in urban environments where nutrient deficient subsoils have often been brought to the surface through construction activities and soil disturbance. Most P in soils is in the inorganic form attached primarily to iron and aluminum, with only 30 to 50% in the organic form. Fertilization with commercial fertilizers mostly builds up the inorganic fraction and it is primarily this inorganic soil P that is measured by soil tests such as the Mehlich 1 extractant that is the basis for soil P recommendations in Virginia. Soil testing is the basis for good nutrient management. A soil test taken from a situation such as homeowner's yard and sent to a soil testing laboratory will enable the owner to know how much P and K is in the soil and therefore how much fertilizer P and K is needed for strong plant growth (Maguire and Heckendorn, 2009). About 97-99% of N in soils is in the organic form, and release of this N is hard to predict as it relies on soil microbes. As the plant available inorganic N tends to be very mobile in soils, fertilizer N recommendations are based on the plant to be grown and immediate growing season uptake needs rather than a soil extraction per se.

It is important to understand that as fertilizer P is held by soils, over-application can build up P above recommended levels and present a long term problem for P loss. However, as N is very mobile it does not build up in soils. Therefore, applications of P should be done according to a soil test and are not required each year, while N applications are generally required each year. Figure 5 below shows an agricultural soil that had P well above what was needed for crop growth. This soil had corn grown and removed with no P fertilization, and despite this annual P removal by the corn crop, it took 15 years for the soil P to drop to where more P fertilizer was required. In urban situations, such as turf where clippings are not removed, soil test P will remain fairly constant over a long time period with no fertilization. One recently published study from Minnesota (Bierman et al., 2010) reported that on sites testing high in soil P, P runoff from turfgrass over a five-year period was significantly reduced without affecting turf quality by not applying any P fertilizer. However, that same study also noted an increase in second-year total P runoff from unfertilized (0 N-P-K) plots due to poor grass growth and sediment/particulate P losses.

Accumulation of P and P-saturation

Most soils retain P very strongly, especially when they are relatively low in P. However, soils have a finite capacity to retain P, and they can therefore become saturated to such a point where they cannot retain more P (Maguire et al., 2005a). As soil P is built up through fertilizer P additions, the strength with which the soil retains P decreases. In practical terms, this means that as soil test P increases, the amount of soluble P (primarily as ortho-P anion) and sediment-bound P lost in runoff also increases (Sims et al., 2002).

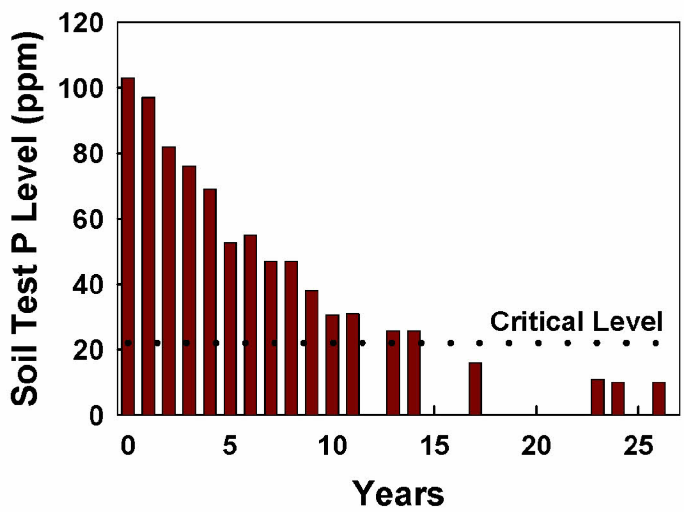

Figure 5. Soil test P with time, where corn was grown and removed for 26 years with no P fertilizer additions (McCollum, 1991). The "critical level" is the soil test value above which no fertilizer P would be recommended for optimum growth.

P-release to leaching and surface runoff vs. P-saturation

There are three main pathways for P losses: 1) leaching, 2) soluble P in runoff, and 3) sediment bound P in runoff (Virginia P Index, 2005). Of these, leaching is only a concern in artificially drained soils, where drains immediately under the topsoil conduct water to streams, and sandy soils. Loss of P in leachate is minimal where the soil test P level is maintained according to recommendations, but rises with overapplication of P fertilizer and saturation of soils with P above levels recommended for plant growth (Maguire and Sims, 2002a, b). For example, P in leachate was below the detection limit until 81 mg Mehlich 1 P/kg, but rose rapidly above this until the leachate concentration was 9.8 mg P/L at 600 mg Mehlich 1 P/kg (Maguire and Sims, 2002b). This compares to an optimum P concentration for turf growth of 55 mg Mehlich 1 P/kg. While P loss in leachate can be a concern in a few cases, soluble and sediment P losses associated with surface runoff are the major P loss pathways in the urban environment. Soil testing is a key component of estimating how much P will be lost through each of these pathways (Maguire et al., 2005a). Soil test levels well above the agronomic optimum raise serious concerns for environmentally damaging P losses, while maintaining soil test P within recommended ranges leads to healthy turf with little risk of environmentally damaging losses. DeLaune et al. (2004) found a linear relationship between soil test P and soluble P concentration in runoff from pastures. Below 36 mg Mehlich 3 P/kg, there was no significant soluble P in runoff, but it increased linearly above this until soluble P concentration was 2.61 mg P/L at 300 mg Mehlich 3 P/kg (relative to optimum for turf growth of 100 mg Mehlich 3 P/kg). Most data relate soil test P to concentrations of P in runoff, and many have related soil test P or soil saturation to P concentrations (Pote et al., 1999). However, loads of P per land area were summarized from data in North America, with total P losses for pasture range from 0.26 to 2.5 lb/ac/yr (0.3 to 2.8 kg P/ha/yr) with a median of 0.8 lb/ac/yr (0.9 kg P/ha/yr) (Young et al., 1996; Beaulac and Reckhow, 1982). As soil test values increase, soluble and sediment P losses in runoff increase, but losses of environmental concern mainly occur above soil test P recommendations (Fig. 6). Since soil test P remains high for many years once built up to excessive levels (Fig. 5), soils high in P will represent a great risk of excessive P losses in runoff for many years. Maintaining healthy turf is a good way to maintain soil cover that minimizes soil erosion and thus sediment bound P losses in runoff. Easton and Petrovic (2004) reported that nutrient losses in runoff were greatest during turf establishment, but that fertilization "ultimately results in less water contamination" as it speeds turf establishment and thus soil stabilization.

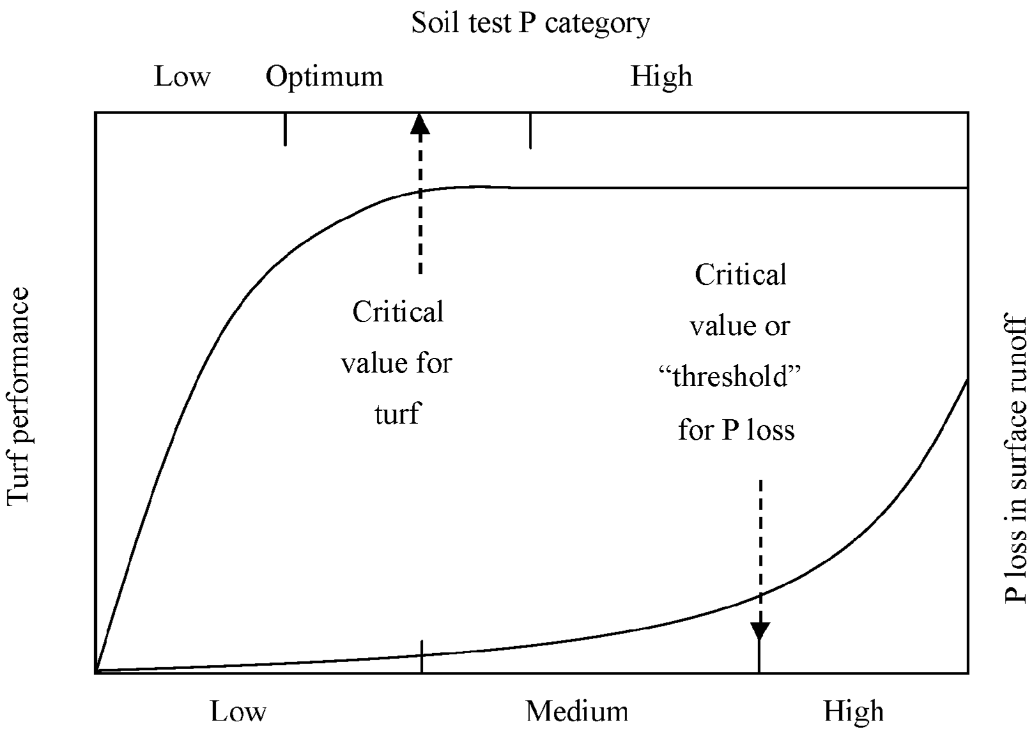

Figure 6. Influence of soil test P on turf performance and P losses in surface runoff (adapted from Sharpley et al., 2002).

Fertilization is important for plant establishment, but should not exceed soil test recommendations. For example, Soldat et al. (2009) found a linear relationship between soil test P and P losses in runoff in turf, with soil test P levels excessive to turf requirements leading to greater P losses in runoff. This is why nutrient management regulations in Virginia, where they are mandated, require that commercial fertilizer P additions are not permitted when a soil test shows that no P is required for optimal plant growth (DCR, 2005). Apart from soil test P levels, many other factors also play an important role in P losses (Maguire et al., 2005b). These include soil type, slope, proximity to streams and drainage and plant cover to avoid excessive soil erosion. The vulnerability of a site to P losses and the relative importance of each of these factors can be determined by a Phosphorus Index (Virginia P Index, 2005). Even under worst-case conditions where fertilizer was applied to turf but not watered-in and a major storm event or simulated event occurred within a few hours of application, the amount of fertilizer N and P lost to runoff was generally less than 10% of applied and, more often, only 2 to 4% of applied

(Walker and Branham, 1992). The levels of P reported during studies of nutrient runoff from turf were sometimes no greater than those reported in natural rainfall (East et al., 1998).

In research comparing the effectiveness of buffer strips of Kentucky bluegrass versus native forb and prairie grasses in handling surface runoff from impervious surfaces, the two systems performed comparably in terms of sediment capture and P loading, even though the Kentucky bluegrass turf was periodically fertilized with P (Steinke et al., 2007). During periods of runoff on non-frozen soils, the turf had lower P loading than the native vegetation, but there were no differences when soils were frozen, regardless of vegetation or size of the buffer. Another source of P that is often overlooked in identifying sources of water pollution is tree leaves. Dorney (1986) reported that up to 9.3% of the total P in the leaves was leachable within 2 hours. As discussed later, lawn clippings are also contain significant P and post a concern for runoff contributions as well.

Soil N in turfgrass management and runoff effects

Forms of soil N and relative availability

Nitrogen (N) is the most dynamic macro-nutrient in soils, rapidly changing between plant-available and unavailable forms. A brief discussion of the nitrogen cycle helps explain why N requires so much attention in turf and landscape fertilization programs. Although N gas makes up 78% of the atmosphere, this form of N is not available to common turf and landscape plants, although some common legume components of lawns (clovers and medics) can form symbiotic relationships with specific N-fixing bacteria that can be captured and ultimately released into the soil in an organic form. The intent of N fertilization in turf and landscape systems defined in the figure is assimilation**,** the uptake and incorporation of N into amino acids, nucleic acids, and proteins. For turfgrass systems, the regular mowing of leaf blades returns clippings (and their N) to the soil where it is decomposed by soil bacterium. This organic N that is found in the decaying plant tissues is converted by the bacteria to the ammonium (NH_4^+) cation during the process of mineralization (also called ammonification). Ammonium is plant available although it is not the primary form of N uptake. It is also important to note that since NH_4^+ is a cation, it resists leaching and can be held and exchanged for other cations in soils with significant net negative charges due to large percentages of clay and/or organic matter. Mineralization is an important ‘recycling’ step in soils.

Ammonium can be oxidized by specific soil bacteria to the primary form of plant available N, the nitrate (NO_3^-) anion in a process called nitrification. This process requires very specific soil-borne bacteria that oxidize NH_4^+ first to nitrite (NO_2^-, a very short-lived compound) and finally the plant-available NO_3^-. Nitrate can also be lost back to the atmosphere by the process of denitrification**,** another series of reactions involving soil-borne bacterium that convert the N back to N_2 gas. Both NH_4^+ and NO_3^- can also be assimilated by some of the same soil-borne bacteria involved in mineralization by what is called immobilization**.** The frequency and speed at which these N conversions occur is a primary reason why soil tests are rarely conducted for N. As indicated in this discussion, there are only two plant-available forms of N, NH_4^+ and NO_3^-.

Nitrogen Sources

Nitrogen sources are frequently categorized according to their water solubility that will be detailed below as readily and slowly-available N. A fertilizer label must state the percentage of total N as well as the varying percentages of water soluble and slowly available N (SAN); SAN can also be identified as water insoluble N (WIN) or controlled release N (CRN) depending on the N source. If there is no detail of SAN, WIN or CRN, then it is assumed that all of the N is water soluble. Since turf and landscape plant materials are most often not being grown for yield (the exception being sod and container/field landscape production systems) and are confined to relatively small land areas as compared to row crop production systems, slowly-available N sources often provide sensible management, cost, and environmental advantages to readily-available N sources. It is important to understand that all N sources will gradually lower soil pH. However, readily available N sources will drop pH much more quickly that slowly-available N sources, a management point that needs to be addressed by soil testing. Each source has different strengths and weaknesses.

Readily-available nitrogen and application rates

Readily-available sources are also referred to as water soluble, quick-release, or fast-acting to designate how quickly they become available following application. The rapid conversion of the fertilizer to the plant-available forms of ammonium (NH_4^+) and nitrate (NO_3^-) is why they provide such a quick growth and color response. As described previously regarding the N cycle, these forms also are readily transformed by chemical and microbial processes into plant-unavailable forms as well. Readily-available sources are less expensive than slowly-available sources of N and can be applied as either liquid or dry formulations. Light and frequent applications of 0.25 to 0.5 lb N/1000 sq ft are desirable, but up to 1 lb N/1000 sq ft in a single application is suitable as long as applications are spaced at least 30 days apart. The level and frequency of the application typically depends on the grass being grown, its intended use, the soil, and the climate. In order to optimize nutrient utilization by the turf, reduce potential injury due to their high salt concentrations, and lessen potential environmental impact from nutrient leaching (especially the highly leachable NO_3^-), an increased frequency of application at lower levels is often desirable. Excessive salt accumulations in the soil can damage roots and/or reduce their function; however, since most areas of the mid-Atlantic receive periodic rainfall, concerns from salt accumulations in the soil from quickly-available fertilizers are limited. The primary concern with turf damage from quickly-available, high salt content fertilizers is the potential for "foliar burn" caused by tissue desiccation. In this scenario, the water soluble, typically high salt content fertilizer that remains on the turfgrass leaves actually attracts water from the cells of the plant; this causes cell and leaf tissue desiccation in localized areas, resulting in the visual foliar burn.

Some of the most common forms of inorganic, readily available N sources used in turf and landscape management are ammonium nitrate, ammonium sulfate, potassium nitrate, calcium nitrate, diammonium phosphate and monoammonium phosphate. The sources with the highest water solubilities (ammonium nitrate, urea, and ammonium sulfate) are often dissolved in water and are foliar applied. The water solubilities and salt indices for these sources are provided in Table 5 below.

Table 5. The grade, salt index, and water solubility of the most common readily-available nitrogen sources used in turf and landscape management fertility programs (after Turgeon, 1985).			
Fertilizer	Grade*	Salt index[z]	Water solubility[y]
	$N-P_2O_5-K_2O$ (%)		Grams/liter (pounds/gallon)
Ammonium nitrate	34-0-0	3.2	1810 (15)
Ammonium sulfate	21-0-0	3.3	710 (5.9)
Potassium nitrate	13-0-44	5.3	130 (1.1)
Monoammonium phosphate	11-48-0	2.7	230 (1.9)
Diammonium phosphate	20-50-0	1.7	430 (3.6)
Urea	45-0-0	1.7	780 (6.5)
[z]The salt index scale is <1 = low, 1 to 2.5 = moderate, and >2.5 = high.			
[y]Water solubility expressed in grams per liter (pounds per gallon in parentheses).			

****Fertilizer grade*** refers to % total N, soluble phosphate (as P_2O_5) and soluble potash (as K_2O). Thus, a 50 lb bag of "10-10-10" would contain 5 lbs each of total-N, soluble phosphate and soluble potash. However, since P_2O_5 is only 44% P by weight, the bag would actually contain 2.2 lbs of actual P. This convention is used to allow uniform labeling because fertilizer forms (particularly P) vary widely. Oxide forms of P and K do not actually appear in commercial fertilizers. Modern soil test levels, fertilizer recommendations and literature runoff values for P are always expressed as "P" and not as P_2O_5.

Slowly-available nitrogen

A unique aspect of N fertilization programs in turf and ornamental management is the use of a vast array of slowly-available N sources that provide very controlled growth and color responses, along with inherent environmental advantages due to the slow-release characteristics. Their use in turf and ornamental systems is typically more economically viable than in production agriculture systems since "yield" is generally not a consideration (except in sod or nursery production systems) and quality, appearance, and playability (in the case of turf), are the driving factors in management programs. The incremental release characteristics of these materials is particularly valuable in turfgrass systems with completely modified, sand-based soils (i.e. sand-based golf greens, tees, and athletic fields) that possess inherently low cation exchange capacities and high N leaching potential.

Slowly-available (SAN) sources of N are also referred to as water-insoluble (WIN), controlled release (CRN), slow-release, and slow-acting to designate their ability to meter out N over a certain length of time, similar to timed-release cold capsules. Using Virginia Department of Conservation and Recreation's Nutrient Management Training and Certification Regulations 4 VAC 5-15 criteria, SAN is defined as "N sources that have delayed plant availability involving compounds which dissolve slowly, materials that must be microbially decomposed, or soluble compounds coated with substances highly impermeable to water such as polymer coated products, methylene urea, isobutylidene diurea (IBDU), urea formaldehyde based (UF), sulfur coated urea, and natural organics". Slowly available N sources provide a sustained growth and color response that lasts for weeks to months rather than providing a quick surge in growth and greening response. Slowly-available N sources also have a very low salt index; hence they do not contribute to a build-up of soluble salts in the soil that might affect root system development. These sources also have minimal foliar burn potential. Because of the added steps involved in their production, they are typically more expensive than quick-release fertilizers. The primary SAN sources used in turf management systems are listed in Table 6 and the products are further described below.

Combinations of quickly and slowly available N

Many manufacturers combine quick and slow release sources of N to take advantage of both strengths. The quick release source provides quick green up but is at a sufficiently low rate to prevent salt injury or reduce the potential for leaching. The slow release source is available to provide a greening response for a longer duration.

Practical considerations in interpreting and applying slowly available N (SAN) sources.

The SAN sources offer advantages from both an environmental perspective as well as reductions in application frequency and controlled plant response. The following application criteria were developed for SAN sources (all categories and combinations of WIN, CRN, etc. apply) in order to optimize plant nutrient use efficiency and environmental responses:

- If the fertilizer is ≥ 50 percent SAN then up to 1.5 lb N/1000 sq ft is acceptable in a single application during optimal growing periods.
- If the fertilizer is 25 to 49 percent SAN then up to 1.25 lbs N/1000 sq ft is acceptable in a single application during optimal growing periods.
- If the fertilizer is ≤ 25% SAN then no more than 1 lb N/1000 sq ft should be applied in a single application during optimal growing periods.

Organic N sources

Organic N sources will likely have SAN percentages as high as 75 to 85%, thus these materials can be applied up 1.5 lb N/1000 sq ft. However, even at these N levels anticipate a very controlled plant response since the N is slowly made available by microbial activity. Depending on the source, composts might contain 1 to 2% N (and likely P) by weight. Again, the majority of the N will be SAN. However, these materials are not normally applied as fertilizers but instead as organic amendments to improve the physical properties (structure, water and nutrient holding capacity etc.) of the soils.

Optimizing N use efficiency

While appropriate N application rates are obviously important in optimizing turfgrass performance, it is also critical to consider the timing of the applications depending on whether the grasses are cool- or warm-season. The most important cool-season grasses used in the United States are Kentucky bluegrass (*Poa pratensis*), hybrid bluegrass (*Poa pratensis* x *P.*

Table 6. A list of slowly available nitrogen[z] (SAN) sources, their typical chemical analyses, and general comments regarding the source.

N source	Typical Grade	General comments about the fertilizer
Natural organics	6-2-0[y]	Derived from waste byproducts; very low N analyses, usually contain some phosphate and other micronutrients; very controlled release that is dependent on microbial activity
Sulfur coated urea (SCU)	32-0-0[x]	Urea granules coated with molten S; analyses and release rate varies depending on amount of coating; N release due to osmosis, so moisture and temperature govern release rate; Relatively inexpensive compared to other SAN sources; will reduce soil pH; handling is important because scratching the coat removes the controlled release characteristic
Polymer coated urea (PCU)	32-0-0[x]	Synthetic polymer is also sometimes combined with S; N analyses variable depending on coating thickness; noted for very predictable release characteristics and handling is not as much of a concern as for SCU in terms of coating integrity
Isobutylidene diurea (IBDU)	31-0-0	Synthetic organic with more than 90% SAN; release is not dependent on microbial activity; quicker release obtained with smaller sized particles, moist soils, and warm temperatures;
Methylene urea	30-0-0[w]	Synthetic organic that can have varying levels of SAN that are defined by their solubility in hot or cold water; N release rates are depending on the chain length of the carbon polymers (higher percentage of short chains increases water solubility); N availability based on microbial activity.
Ureaformaldehyde (UF)	38-0-0	Synthetic organic with predominantly long chain carbon polymers and very controlled N release; N availability based on microbial activity; very limited response in cold temperatures.

[z]Slowly available nitrogen (SAN) is used as a comprehensive term for N availability and includes sources also identified as water insoluble N (WIN) and controlled release N (CRN). In general, SAN is 2x - 5x as expensive than soluble-N forms like urea.

[y]N analyses variable depending on the source.

[x]N analyses variable depending on the coating thickness.

[w]The percentage of SAN varies depending on the source.

arachnifera), tall fescue (*Festuca arundinacea*), perennial ryegrass (*Lolium perenne*), the fine-leaf fescues of creeping red (*Festuca rubra)*, chewings (*F. rubra* ssp. *Fallax*), and hard fescue (*F. brevipila*), creeping bentgrass (*Agrostis stolonifera* var. *palustris*), annual ryegrass (*Lolium multiflorum*). Even though they all have different potential uses, they each are best adapted to temperatures of 65 to 80^{o} F.

The seasonal pattern of roots, shoots, and carbohydrate storage (i.e. food) for cool-season grasses is shown in Figure 7. As a rule of thumb, the optimal time to fertilize any grass is during periods when roots are developing. There are two 'windows of opportunity' for optimal N fertilization: a primary window during the fall and a secondary window in mid-spring. Approximately ¾ of the seasonal N should be applied in the fall; warm soil temperatures and cooling air temperatures are an ideal combination that promotes desirable increases in roots, shoots, and carbohydrates. While spring presents the greatest increase in root development, aggressive N fertilization can promote shoot growth at the expense of roots and carbohydrates. A small amount of N (typically up to 1 lb N/1000 sq ft for the season) is beneficial. Unfortunately, spring is the period when human nature and savvy marketing sells the most fertilizer and it is common that homeowners regularly over apply N fertilizer. The applications result in an aesthetically pleasing, lush green turf, but because of the emphasis on the shoot system over the roots and carbohydrate storage, the turf often struggles during periods of temperature and moisture extremes in the summer.

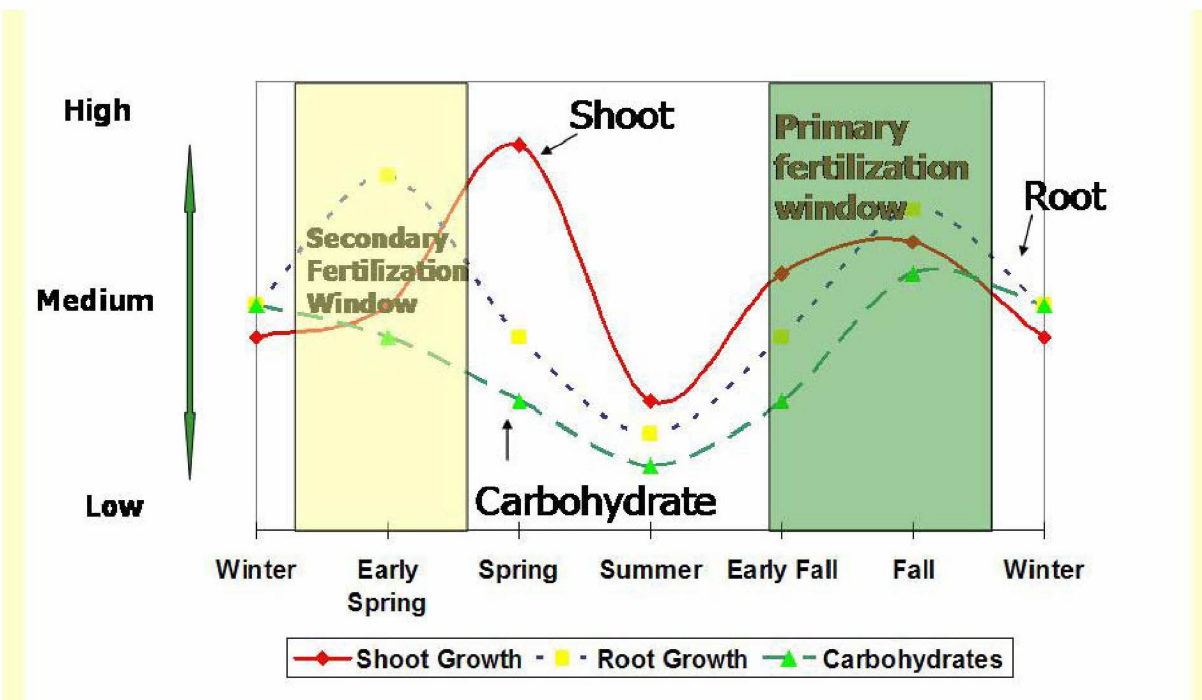

Figure 7. The seasonal growth and response patterns of shoots, roots, and carbohydrates of cool-season grasses.

Also, it is important to realize that even though the grasses respond to the temperatures similarly, different species have varying N needs. For instance, Kentucky bluegrass has a very high annual N requirement (up to 3.5 lbs per 1000 sq ft), while fine leaf fescues' seasonal N requirement might be only 1 to 2 lbs N per 1000 sq ft. Table 7 provides typical seasonal N levels and strategies to optimize the application response for cool-season grasses.

Table 7. General seasonal nitrogen fertilization strategies for cool-season turfgrasses.

Time of Year	**Relative N Rate/Application**	**Comments**
Early Spring	None to low (0.25 lb N/1000 sq ft/growing month)	-Never apply to frozen ground -if following aggressive fall fertilization, probably not necessary
Mid-late spring	Low to Medium (0.25 to 0.5 lb N/1000 sq ft/ growing month)	-have been shown to benefit root growth with responsible applications -exceeding these levels promotes shoots at expense of roots
Summer	None to low (0.25 lb N/1000 sq ft/growing month)	-in general, refrain from N fertility, but small amounts can aid recovery from stress/pest pressures… avoid applications during high heat/drought pressures
Late summer thru early winter	Medium to high (0.5 to 1 lb N/1000 sq ft/growing month)	-Promotes recovery from summer stress with early fall applications -Continue program (while grass is still green without much shoot growth) to promote roots, color, turf density and carbohydrate levels.

The primary warm-season grasses are bermudagrass (*Cynodon* spp.), zoysiagrass (*Zoysia* spp.), centipedegrass (*Eremochloa ophiuroides*), and St. Augustinegrass (*Stenotaphrum secundatum*). These grasses are best adapted to temperatures of 80-95° F. Seasonal growth and carbohydrate patterns are detailed in Figure 8. These grasses enter dormancy in late fall after repeated frosts and do not renew active growth until mid-spring. Similar to cool-season grasses, aggressive spring fertilization with N is risky as it promotes shoot growth at the expense of the roots and carbohydrate system. It is desirable to wait on spring N fertilization until after the last average frost date has passed. After spring greening is complete, regular fertilization with N is possible through the remainder of the summer and into early fall. As cooler temperatures arrive, N fertilization should be reduced as the grasses begin to prepare for winter dormancy. As for cool-season grasses, the seasonal N requirements vary between species. For example, bermudagrass might have a seasonal N requirement of up to 4.5 lbs N per 1000 sq ft on heavy use turfs, whereas zoysiagrass will likely only receive 1 to 2 lbs N per 1000 sq ft per season.

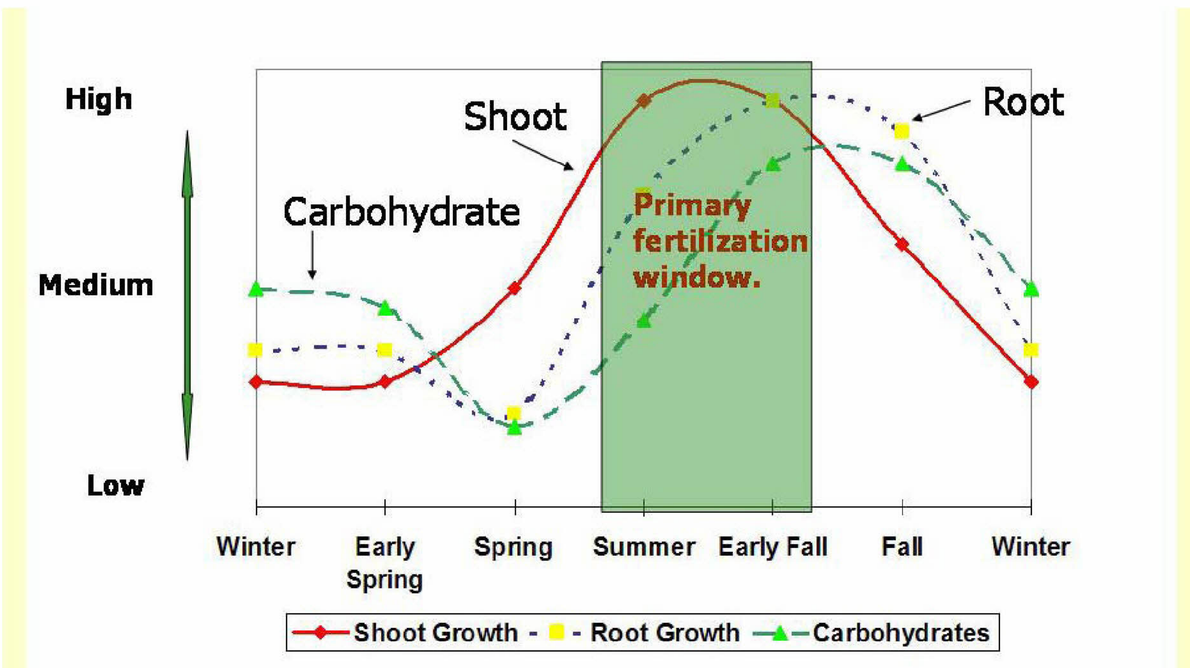

Figure 8. The seasonal growth and response patterns of shoots, roots, and carbohydrates of warm-season grasses.

Nitrogen application rates and strategies for warm-season grasses are presented in Table 8. As before, the seasonal levels will vary depending on the grass as bermudagrass can respond positively to up to 4.5 lbs N per 1000 sq ft on an annual basis, whereas zoysiagrass and centipedegrass likely only need 1 to 2 lbs N per 1000 sq ft.

Table 8. General seasonal nitrogen fertilization strategies for warm-season turfgrasses.

Time of Year	Relative N Rate/Application	Comments
Early Spring	None to low (0.25 lb N/1000 sq ft/every 30 days of optimal growing conditions)	-Never apply to frozen ground -Ideally wait until complete greening, but strategy doesn't fit standard weed and feed products designed for PRE crabgrass control
Mid-late spring	Low to Medium (0.25 to 0.5 lb N/1000 sq ft/ every 30 days of optimal growing conditions)	-excessive levels promote shoots at expense of roots -be aware of average "last frost" dates for the area
Summer	Medium to High (0.5 lb to 1 lb N/1000 sq ft/every 30 days of optimal growing conditions)	-primary season for fertilization, but still wise to avoid applications under severe environmental stress
Late summer to winter dormancy	Low (0.25 to 1 lb N/1000 sq ft/every 30 days of optimal growing conditions)	-maintaining active growth until dormancy promotes late season rooting and carbohydrate storage but N applications terminated prior to first frost date

Runoff losses from established turfgrass

A dense turf is a strong deterrent to runoff. Linde and Watschke (1997) reported no detectable sediment in approximately 83% of 237 runoff samples from creeping bentgrass and perennial ryegrass turf. Even under worst-case conditions where fertilizer was applied to turf but not watered-in and a major storm event or simulated event occurred within a few hours of application, the amount of fertilizer N and P lost to runoff was generally less than 10% of applied and, more often, only 2-4% of applied (Walker and Branham, 1992). Runoff N losses in cool-season turfgrasses has been reported as minimal (Gross et al., 1990; Morton et al., 1988). Similar results were reported for a St. Augustinegrass lawn on a 10% slope (Erickson et al., 2001). Responsibly managed turfgrasses have generally been observed to have little N leaching and/or runoff potential (Gross et al., 1990; Miltner et al., 1996). Henry et al. (2002) detail that if fertilizer is applied directly to turf, there is very little chance of unintended environmental consequences, but if it ends up on impervious surfaces it is potentially a major source of water pollution since it can enter stormwater drains.

In a comparison of a mixed-species landscape and a St. Augustinegrass turf on a medium-textured sand soil in FL, the turfgrass system had a 10x reduction in N leaching even though it received 2x greater seasonal N levels (Erickson et al., 2001). A muck-grown St. Augustinegrass sod had significantly less nitrate and phosphate leaching than a sand-based sod during establishment, with the potential reductions in leaching being increased by delaying the initial fertilization until 30 days after installation (Erickson et al., 2010). Bell and Koh (2009) reported that under normal rainfall conditions a bermudagrass golf course fairway in OK lost 0.5% N and 2% P in surface runoff, and under record rainfall conditions, the loss was 1.3% of applied N and 7.7% P. Bermudagrass buffers of various widths and clipping heights were highly effective in reducing nutrient and pesticide movement, with the primary effect being dilution of the chemical applied (Cole et al., 1997). Further research demonstrated that employing graduated buffers (maintaining strips of turf at increasing cutting heights as they approach water's edge) resulted in 17% less N, 11% less P, and 19% less runoff volume during 60 min of natural rainfall runoff (Moss et al., 2005). The graduated buffer resulted in 18% less N and 14% less P during 60 min of irrigation runoff, and reduced runoff volume by 16% for simulated bermudagrass golf fairways.

Lawn clippings management

In addition to direct runoff from fertilizer applied N and P, mis-management of lawn clipping can also have significant effects on nutrient runoff levels. Research in MN indicated that clipping management (recycled to the turf or collected) was not an important factor for P runoff, indicating that returning clippings to the turf canopy does not significantly increase P runoff (Bierman et al., 2009). However, clippings that are deposited on hardscapes (impervious surfaces) that are washed into stormwater drainage do pose significant risk. Shapiro and Pfannkuch (1973) concluded that street sweeping to remove organic debris would reduce P loading of urban lakes from stormwater, but that removal of P from lawn fertilizers would "not materially reduce concentrations of P in runoff ". Waschbusch et al. (1999) reported that lawns and streets were responsible for most of the P transported to the lakes in runoff and that home lawns were the largest single source of both total and dissolved P and at least 25% of the Total-P was associated with vegetative material. Oak leaves have also been reported (Dorney, 1986) to contribute significant P to urban runoff waters. Once in stormwater basins or other deposition zones, lawn clippings and other vegetation can release substantial amounts of their total N and P content to the water column (Strynchuk et al., 1999) within 30 days.

Importance of soil testing and balanced nutrition

Nitrogen and P solubility, availability and plant uptake are strongly controlled by soil pH. Similarly, the viability of the soil microbial biomass that is critical to N and P transformations over time is also highly pH dependent. Therefore, any effective nutrient management program needs to ensure that the soil pH is within the adequate range for the managed vegetation. For turf, this range is typically between pH 6.0 and 7.5, but it may be lower (e.g. 5.0 to 6.0) for certain acid-adapted grasses and native trees. It is therefore critically important that fertilizers only be applied to soils within the appropriate pH range to ensure adequate plant and soil microbial uptake to limit runoff and leaching loss potentials.

Summary and Synthesis

It is clear from our review of the scientific literature and our personal research experience that implementation of a wide range of fertilizer management practices and/or policies could significantly reduce total stormwater runoff of both N and P. However, there are very few published and publically available studies that actually measure the extent and timing of those reductions. The most optimistic estimate would be up to a 25% reduction within the first year with an expectation of continued reductions over time, particularly for total P. However, we also feel it is quite possible that even greater short- and long-term reductions in runoff N and P would be achievable if a combination of the practices described below were fully implemented.

The collective scientific literature on N-fertilizer application and management in intensively managed urban turfgrass systems clearly indicates that by carefully restricting application rates (e.g. no more than 1 1b/1000 ft^2 of soluble N at least 30 days apart for cool season grasses), that N runoff losses will be quite minimal. Certainly, intensive N fertilizer management as described herein will be superior to more infrequent and heavier applications (e.g. one time in the fall) which are common. However, this more intensive management approach will require two or more split applications per season for optimum turf management. Similarly, appropriate use of slow-release N fertilizers or carefully prescribed rates of labeled organic-N sources would also significantly reduce the risk of N runoff losses. However, slow release sources (e.g. polymer/sulfur coated urea) are two the three times as expensive per pound of N applied when compared with conventional soluble granular urea. Labeled organic sources of N can be 4 to 5 times as expensive per pound of N applied.

It is also clear that restricting P-fertilizer applications to urban soils to correspond to actual plant needs (via soil testing) is the most effective way to reduce P-runoff losses over time. However, limiting long-term P release from soils that have received repeated and excessive fertilizer applications will be challenging. For example, an urban soil that contains 100 ppm (mg/kg) of soil-test P contains 200 lbs per acre of P in relatively bioavailable forms in the upper six inches of soil. That P is readily available for plant uptake and deposition in clippings and a considerable portion will be available for desorption into runoff waters over time. Thus, it may take many years for runoff loadings from these high P soils to decline significantly.

Collectively, we believe that the single most important factor or practice for reducing short-term nutrient runoff would be to limit or prevent application of fertilizers directly onto sidewalks, driveways and other impervious surfaces. This can be readily accomplished by use of drop spreaders or liquid spray fertigation equipment rather than conventional spin/rotary spreaders. Unfortunately, this latter type (spin/rotary) is the most commonly employed by homeowners and readily broadcasts fertilizers several feet beyond the turf and onto adjacent impervious areas. However, this type of fertilizer can be moved back onto targeted areas and off the impervious surface by using leaf blowers. Similarly, lawn clipping and other vegetative wastes should be carefully controlled, removed from impervious surfaces, and not allowed to accumulate on turf edges or in low spots where they can readily be entrained into runoff following storm events.

In context, however, it is essential to point out that both N and P fertilization are required for establishment of new vegetation on construction sites and in newly prepared and landscaped areas. Similarly, adequate soil N and P must be available to sustain desired turf and landscape plantings over time and appropriate applications should be made to N- and P-deficient soils where those limitations are clearly apparent and documented.

Loss of sediment-bound N and P will be negligible from established and well-managed home lawns and landscapes. However, where site development and construction removes established vegetation and litter layers, the highest risk is clearly associated with previously P-enriched topsoil layers. These materials should be carefully segregated and protected on-site, seeded to a temporary vegetative cover, and surrounded by silt fences, compost berms or other appropriate sediment control BMPs. While exposed subsoil materials (typically Fe and clay-rich B and C horizons) may pose a significant short-term site specific risk for sediment loss, their effect on nutrient levels in runoff is negligible.

With respect to various management practices and regulatory control measures discussed earlier in this paper, we have the following conclusions and suggestions. First of all, we **do not** support an across-the-board ban on all N and P fertilizer applications (**Option A**) for the simple reason that we simply cannot establish and maintain healthy vegetation to control soil erosion and filter sediment out of overland flow/runoff without adequate plant-available N and P. Thus, adequate (but limited) applications of N and P must be allowed for new seedings on construction and redevelopment sites and for areas where the soil/vegetation system is clearly nutrient deficient. **Option B** (*Ban on P except for new seedings or critical areas; slow-release N formulations only*) would be the most readily applicable option for individual home lawns that are not serviced by commercial lawn care providers and/or certified applicators. This option assumes that previous P fertilization to established lawns has led to significant soil P enrichment, but would allow limited P applications to new seedings or turf renovation where supported by site-specific and current soil testing. The minimum SAN content (see page 18) of commercially available fertilizers would need to be specified in order for Option B to be implemented and the added cost per pound of N applied may affect homeowner acceptance. A slightly less restrictive policy (**Option C**) would require that all P-fertilizer applications be based on a current soil test to limit P applications to actual plant needs. This would also ensure that soil pH is adequate to maximize plant/ microbial P-uptake. When coupled with strict one-time and annual N loading limits, this option closely resembles current intensive turf management practices as specified by Virginia DCR for areas under Nutrient Management Plan restrictions.

Secondly, we strongly believe that policies that restrict or prevent the application of fertilizers onto impervious services and mandate the removal and safe disposal of grass clippings and other vegetative materials are warranted and could potentially have the greatest impact on short-term nutrient runoff levels for both N and P **(Option D).** Furthermore, as discussed above, we strongly believe that all P applications to urban lawns and landscapes should be based on soil test recommendations and that all N applications should be limited in both total annual and one-time application amounts as described above. Use of slow-release N fertilizers and properly analyzed and labeled organic nutrient sources should be encouraged and integrated into intensive soil/plant nutrient management systems where available and appropriate **(Options B and E).** However, both of these options would require the use of more expensive N and P fertilizers and greatly increased management inputs.

Widespread implementation of these recommendations would clearly be daunting for the general public, but readily accepted by lawn care professionals and the commercial landscaping industry. Where nutrients are being applied by commercial entities, newly enacted Virginia legislation (regulated by VDACS; 2008) will greatly assist in implementation (**Option F**) but these provisions currently do not apply to homeowners and other non-commercial nutrient applicators. In order to control and optimize nutrient management by individual citizens on their own property, a system whereby fertilizer sales are limited by soil testing documentation would be required along with some independent measure or homeowner certification of actual size of lawns or fertilized areas. Clearly, we would expect resistance by homeowners to these restrictions.

Overall Conclusions

Taking all potential options into account, we believe that a combination of **Options B, D and F** would be the most effective for both short- and long-term reductions in N and P loadings to stormwater runoff from individual home lawns and landscaped areas. Alternatively, where fertilizers are applied by commercial entities or certified individual applicators, the prescriptions laid out in **Option C** should be rigorously followed. Implemented together, these combined practices would (1) limit P applications in all settings to those prescribed by a current and valid soil test and (2) strictly limit total annual and one-time N application rates. Concurrently, (3) local policies should be established to ensure that fertilizers and clippings are not allowed to be applied and/or retained on impervious surfaces. Finally, where required and necessary, (4) fertilizers should be prescribed and managed by certified applicators.

There are very few studies currently available that directly measure the effects of reduced or limited N and P fertilization practices on runoff nutrient loadings. Several available studies indicate a potential 25 to 50% reduction in total-P loading to stormwater within several years following implementation of P-fertilizer bans or stringent soil-test based limitations. The scientific literature also indicates that intensive N management can minimize or largely eliminate direct runoff losses from turfgrass; thus, we would also expect significant reductions of 10 to 20% in total N loadings to stormwater. However, these predictions are based on a very small set of published (and largely non-refereed) studies. Catchment-specific runoff studies and monitoring would be required to validate and confirm the response of actual N and P runoff loadings to actual changes in application rates and management practices.

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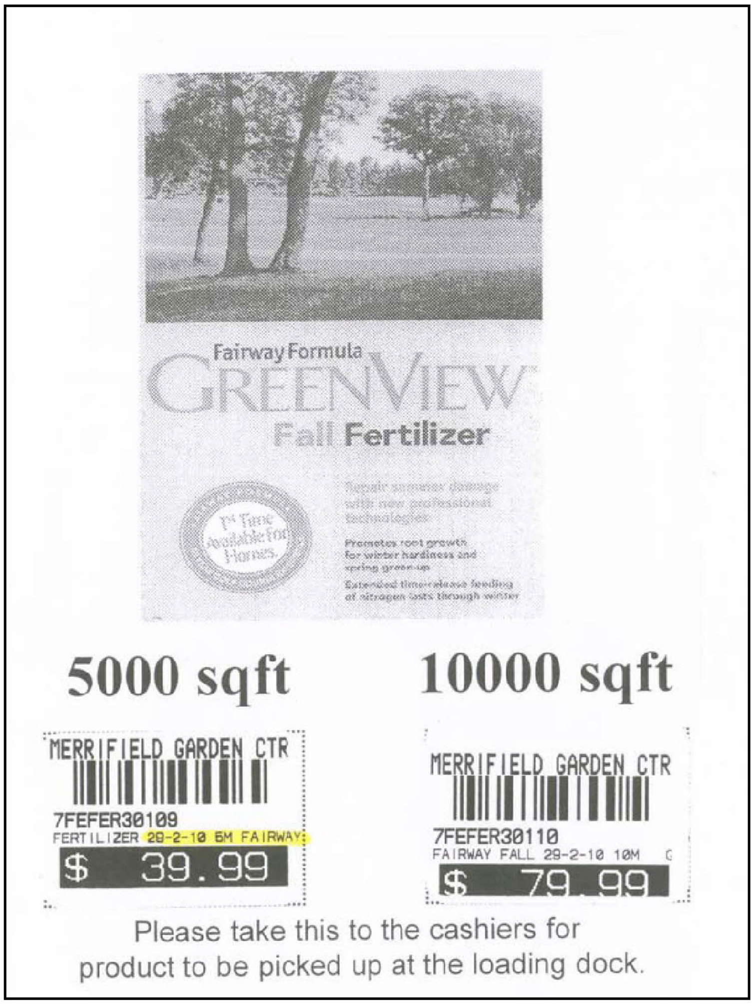
Exhibit 6

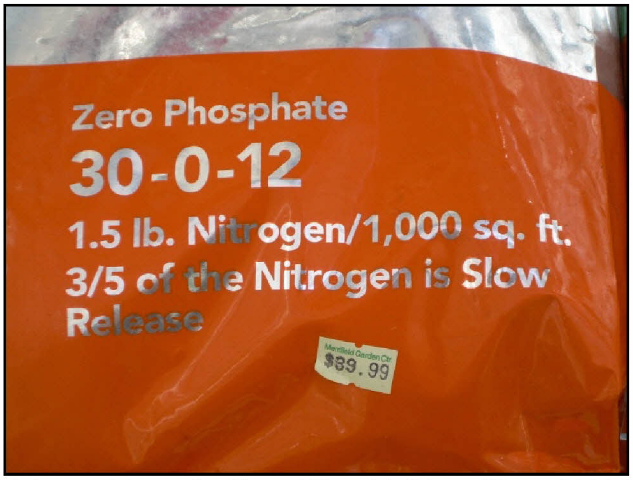
Availability of Phosphorus-Free Fertilizer

Exhibit 6: Availability of Phosphorus-Free Fertilizer

The following photos were taken at Merrifield Garden Center in Gainesville, Virginia, on November 2, 2010, to document the availability and relative cost of Phosphorus-free and Slow-Release Nitrogen (SRN) fertilizer to standard fertilizer formulations. The following photos show a single brand, Fairway Formula, with three different formulations: 29-2-10; 30-0-12 (with 3/5ths SRN); and 31-0-0 (with 9/10ths SRN), each at the same price point. From these photos, it is evident that Phosphorus-free and SRN formulations do not need to cost more than traditional fertilizer.



Fairway Formula GreenView Fall Fertilizer (5,000 s.f. coverage), 29-2-10: $39.99



Fairway Formula GreenView Fall Fertilizer (5,000 s.f. coverage), 30-0-12, No Phosphorus and 3/5ths SRN: $39.99

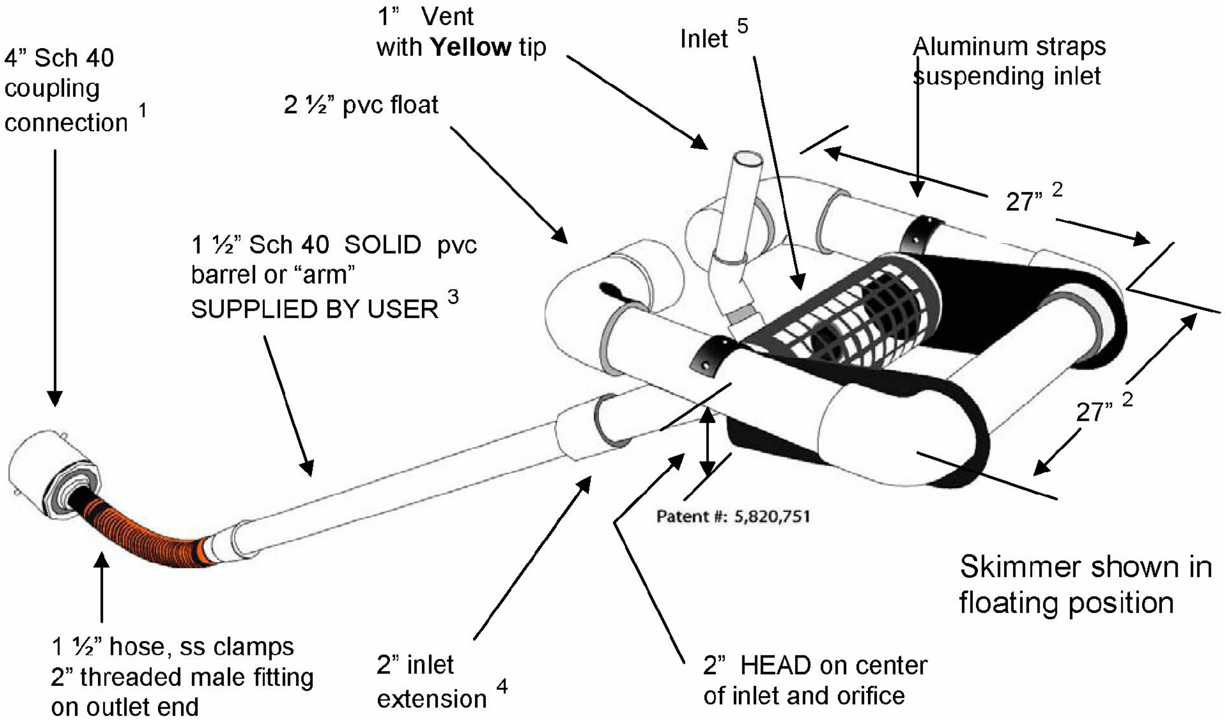
Fairway Formula GreenView Late Fall Fertilizer (5,000 s.f. coverage), 31-0-0, No Phosphorus and 9/10ths SRN: $39.99

Exhibit 7

Faircloth Skimmers

2” Faircloth Skimmer® Cut Sheet

J. W. Faircloth & Son, Inc.
www.FairclothSkimmer.com



1. Skimmer can be attached to a straight 4” sch 40 pipe through the dam but the pipe may need to be anchored to the bottom at the connection so it is secure. Coupling can be removed and hose attached to outlet using the threaded 2” fitting. Typical methods used: on a metal structure a steel stubout welded on the side at the bottom side with a 2” threaded coupling or reducers; on a concrete structure with a hole or orifice at the bottom, use a steel plate with a hole cut in it and coupling welded to it that will fit over the hole in the concrete and bolted to the structure with sealant; grout a 4” pvc pipe in a hole in the concrete to connect the skimmer.
2. Dimensions are approximate, not intended as plans for construction.
3. Barrel (solid, not foam core pipe) should be 1.4 times the depth of water with a minimum length of 6’ so the inlet can be pulled to the side for maintenance. If more than 8’ long weight may have to be added to inlet to counter the increased buoyancy.
4. Inlet tapers down from 2” maximum inlet to a 1 ½” barrel and hose. Barrel is smaller to reduce buoyancy and tendency to lift inlet but is sufficient for flow through inlet because of slope. The inlet orifice can be reduced using the plug and cutter provided to control the outflow rate.
5. Inlet is 4” pipe between the straps with aluminum screen door for access to the inlet and orifice inside.
6. **Capacity** 3,283 cubic feet per day maximum with 2” inlet and 2” head. Inlet can be reduced by installing a smaller orifice using the plug and cutter provided to adjust flow rate for the particular basin volume and drawdown time required.
7. Shipped assembled. User glues inlet extension and barrel, installs vent, cuts orifice in plug and attaches to outlet pipe or structure. Includes flexible hose, rope, orifice cutter, etc.